Thyristor power units

TC3000

Three-phase load control

User
Manual

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Part No : HA174835 ENG - Issue 3.1 - 06/01 (Old part No : HA 174836)

CE

EUROPEAN DIRECTIVES

SAFETY

The **TC3000** products installed and used in accordance with this User Manual are designed to comply with the essential protection requirements of the European Low Voltage Directive 73/23/EEC dated 19/02/73 (amended by Directive 93/68/EEC dated 22/07/93).

CE MARK

The CE Mark of **TC3000** products implies that the essential protection requirements of the European Low Voltage Directive are observed.

The **TC3000** Technical Construction File is approved by a Notified Body, **LCIE** (Laboratoire Central des Industries Électriques).

CE DECLARATION OF CONFORMITY

A CE Declaration of Conformity is available on request.
For further information on CE Mark, please contact your nearest Eurotherm office.

ELECTROMAGNETIC COMPATIBILITY (EMC)

For industrial environments, excluding residential environments

The **TC3000** products are considered as components without any direct function as defined in the EMC Directive. The system or installation in which these products are incorporated must complies with the essential protection requirements of the EMC Directive.

However, Eurotherm certifies that the **TC3000** products, when installed and used in accordance with their User Manual, meets the following EMC test standards and enables the system or installation in which there are installed to comply with the EMC Directive in regards to the **TC3000** products.

EMC TEST STANDARDS

EMC tests		EMC test standards	
Immunity	Electrostatic discharge	EN 61000-4-2	(06/1995)
	Fast transients	EN 61000-4-4	(01/1995
	Radioelectric frequency electromagnetic fields	prEN 61000-4-3	(1984)
Emission	Radiated and Conducted	EN 55011-2	(1991)
	The choice of the **Condacted Emission** applicable standard depends on the application: • EN 50081-2 (1991) - Without external filter in Burst firing on resistive load up to 250 A nominal - With an external parallel filter in Burst firing on resistive load for 300A to 500 A - With an external series filter for other configurations • prEN 61800-3 (1996) Without external filter. Applies for the second environment		

VALIDATION BY COMPETENT BODY

In order to guarantee the best service, Eurotherm has validated the compliance of the **TC3000** products with EMC test standards through design and laboratory tests that have been validated with a Technical Construction File by a Competent Body, **LCIE** (Laboratoire Central des Industries Électriques).

EXTERNAL SERIES FILTERS

To reduce the conducted emissions that occur when using thyristor units, Eurotherm can supply external filters.

Nominal current of TC3000	Serial filter order code
25 A to 60 A	FILTER/TRI/63A/00
75 A and 100 A	FILTER/TRI/100A/00

For 150 A to 500 A nominal current consult your Eurotherm ofice

EMC INSTALLATION GUIDE

In order to help you reduce risks related to the effects of electromagneticinterference depending on the installation of the product, Eurotherm can supply you with the "**EMC Installation Guide**" (Part No. HA025464).
This guide gives the rules generally applicable for Electromagnetic compatibility.

MANUALS IN USE

This **TC3000 User Manual Part No HA174835 ENG (Old Part No: HA174836)** intended for the TC3000 series power thyristor units manufactured beginning **January 1996.**

The TC3000 User Manual Part No HA172247 is valid for products manufactured before this date.

PRECAUTIONS

Important precautions and special information are indicated in the manual by two symbols:

DANGER

This symbol means that failure to take note of the information may have serious consequences for the safety of personnel and may even result in the risk of electrocution.

ATTENTION

This symbol means that failure to take note of the information may
- **have serious consequences for the installation**
- **result in the incorrect functioning of the power unit.**

These marks must indicate specific points. The entire manual remains applicable.

PERSONNEL

The installation, configuration, commissioning and maintenance of the power unit must only be performed by a person **qualified and authorised to perform work in an industrial low voltage electrical environment.**

INDEPENDENT SAFETY

It is the responsibility of the user and it is highly recommended, given the value of the equipment controlled using TC3000, to install **independent safety** devices. This alarm must be tested regularly.
Eurotherm can supply suitable equipment.

FURTHER INFORMATION

For any further information and if in doubt, please contact your EUROTHERM office where technicians are at your disposal should you require advice or assistance with the commissioning of your installation.

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Chapter 1

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Chapter 1 IDENTIFYING THE THYRISTOR UNITS

GENERAL INTRODUCTION TO THE TC3000 SERIES

The **TC3000** series thyristor units are designed to **control the electrical power** on **industrial three-phase** loads.

The **TC3000** series is designed to control the following loads:

- inductive (inductors or primary transformer coils),
- resistive (with low temperature coefficient),
- composed of short wave infrared elements.

The three-phase loads can be connected

- in star with neutral
- in star without neutral
- in closed delta
- in open delta.

The **TC3000** thyristor units current ratings are from **25 A** to **500 A**.

The nominal line-to-line voltage can be between **100 V** and **500 V**.

The thyristor unit connection is **indifferent** to the order of the power supply phase rotation.

A **TC3000 s**eries thyristor unit is composed of **3 channels** containing a pair of thyristors mounted in anti-parallel.

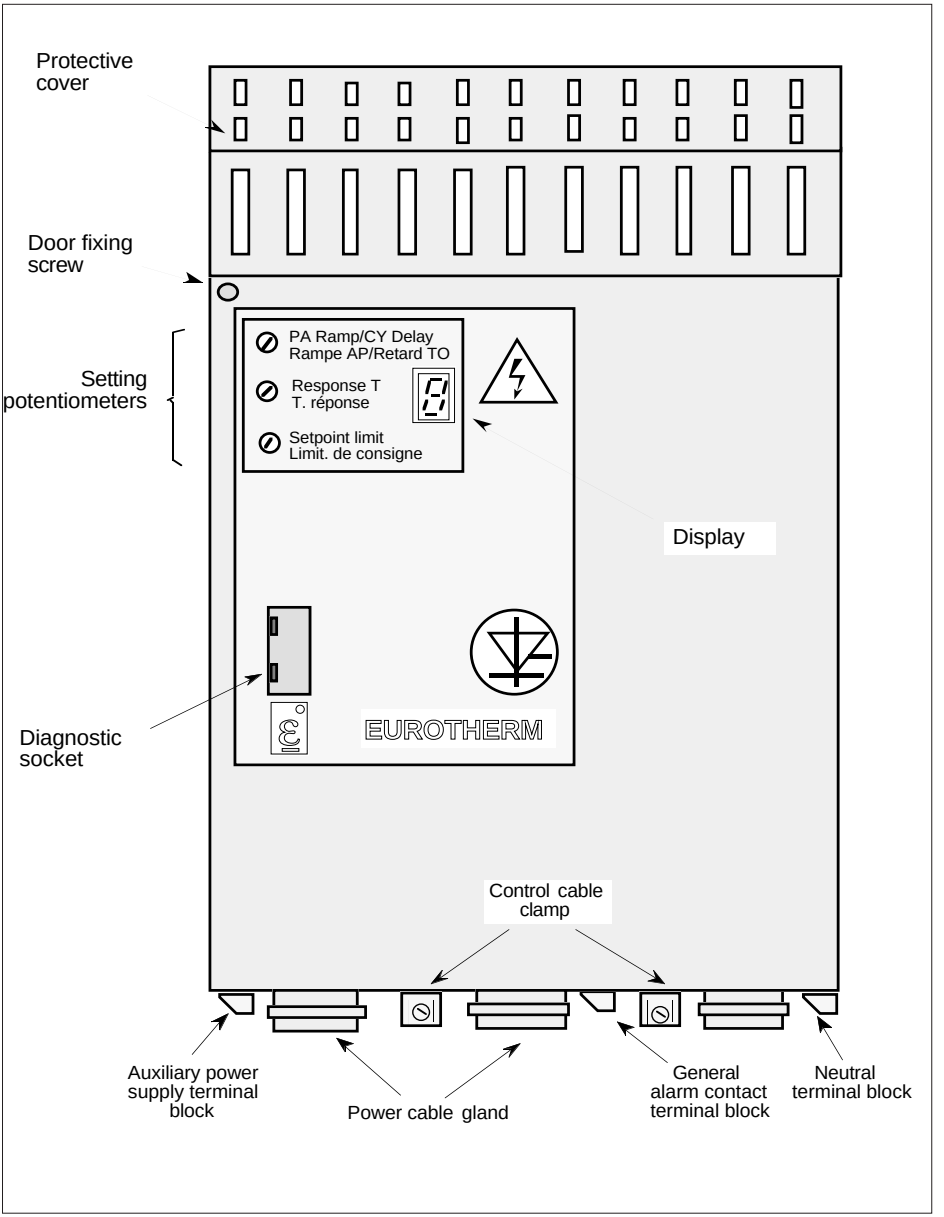

Figure 1-1 Overall view of the TC3000 thyristor unit

The **TC3000** thyristor units have the following **functions**:

- two **control** modes:
  - **V^2**
  - external measurement signal
- several thyristor **firing** modes:
  - logic (ON/OFF),
  - thyristor firing angle variation (Phase angle),
  - cycle time modulation (Burst firing mode),
  - soft operation: adjustable soft start and/or stop to eliminate over-currents on loads with low resistance when cold or for other applications
- **permanent monitoring** of the power supply voltage and the frequency.

The thyristor unit is controlled with **analogue** or **logic signals**.
For the input analogue signals, there are four possible voltage levels:

0-5 V ; 1-5 V ; 0-10 V ; 2-10 V

and two current levels:

0-20 mA and **4-20 mA.**

The instantaneous state of the thyristor unit, its operating mode and the active state of alarms are indicated by messages on a 7 segment **display** located on the front panel.

The front panel also includes:

- **3 setting potentiometers** for the main operating parameters
- a **diagnostic** socket.

An **alarm** system detects abnormal variations in the voltage and frequency and failures of the neutral when used or the external measurement circuit.

Failure detection **is signalled** by the contacts of two alarm relays and by the display.

A **TC3000** thyristor unit is equipped with:

- a thyristor firing board ('**power board**') which generates thyristor firing pulses and measures the voltage,
- a '**driver board**' for the auxiliary power supply, the control circuit and the signal and operating mode configuration,
- a '**potentiometer board**' for the calibration of the thyristor unit current and voltage and for the setting of the main operating parameters,
- '**filter boards**' to protect the thyristor unit operation against transient interference.

The user terminal blocks below the thyristor unit are used for the following connections without having to open the front door:

- the auxiliary power supply,
- the reference neutral,
- the alarm relay contact.

The **filters** providing immunity against electromagnetic interference are fitted:

- at the reference neutral connection input,
- between the power supply phases ('LINE') and the safety earth connector,
- between the load connections ('LOAD') and the safety earth connector,
- between the power phases (for 300 A to 500 A nominal units).

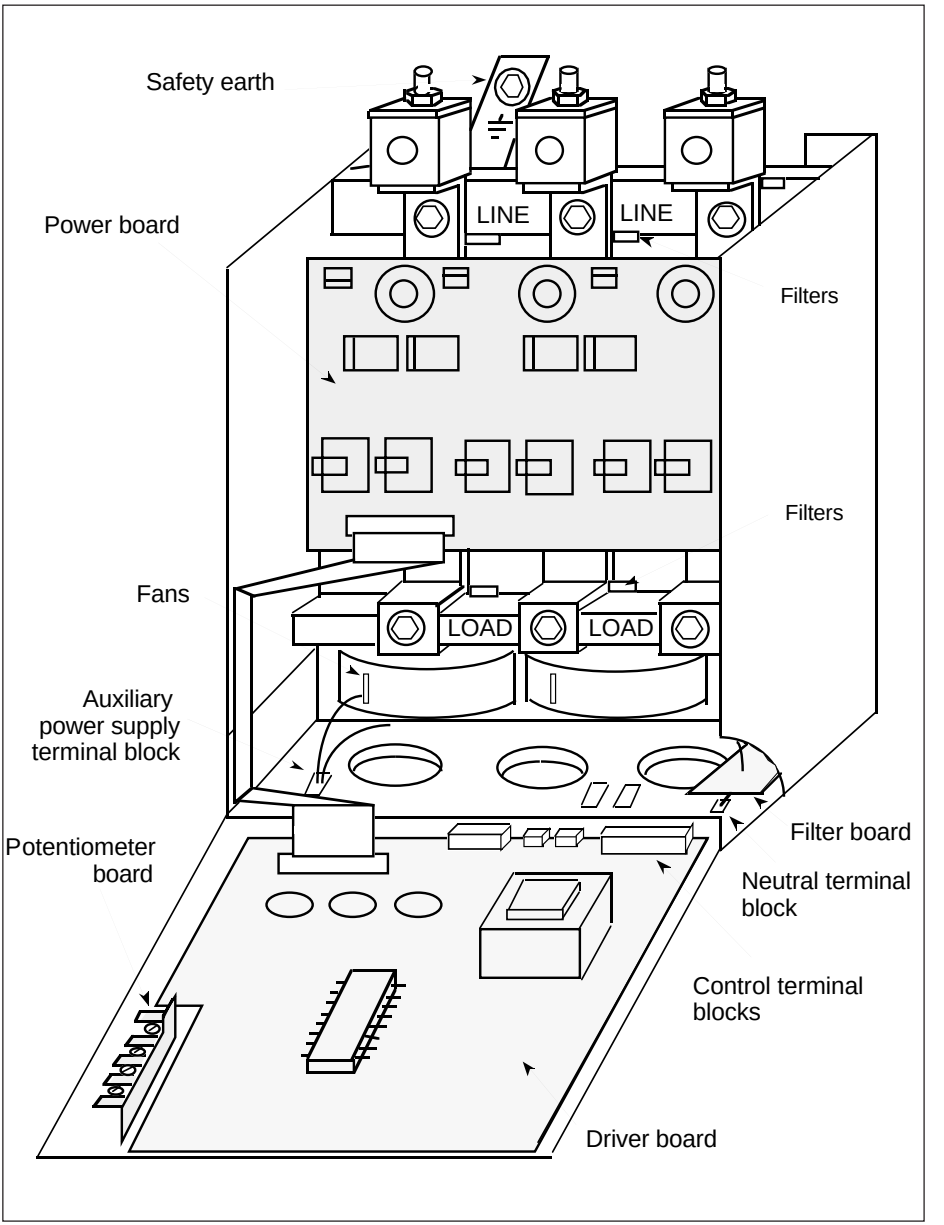

Figure 1-2 TC3000 thyristor unit electronic boards

TECHNICAL DATA

The TC3000 series is a series of power thyristor units designed for the control of 3 phases of industrial three-phase loads using thyristors.

Warning !

An isolating device must be installed between the equipment and the mains supply in order to perform the maintenance in complete safety.

Thyristors are not isolating devices.
Touching load terminals, even if there is no loads current (unit in the off-state), is as dangerous as touching power supply terminals.

Caution !

It is the user's responsibility to ensure that the nominal values of the thyristor unit are compatible with the conditions of installation and operation before commissioning the thyristor unit.

Power

Nominal current (per phase)	**25 A** to **500 A**
Nominal line-to-line voltage	**240 V** to **500 V** (+10%,-15%)
Operating voltage (calibration)	**100 V** to **500 V** Inhibit below 70% (or 50%) of calibrated voltage
Power supply frequency	**42 Hz** to **68 Hz** Automatic adaptation Inhibit outside 40 to 70 Hz
Dissipated power	**1.3 W** (approximately) per ampere and per phase
Cooling	**Natural** convection (**25 A** to **75 A**) **Permanent** fan cooling from **100 A**
Fans	**2** for **100 A** to **250 A**, **3** for **300 A** to **500 A** Consumption **25 VA** per fan Power supply voltage **115 V** or **230 V** (same as electronics supply)
Load	**Industrial three-phase** load: resistive, short wave infrared, inductive
Load connection	I**ndependent** of the phase rotation order
Load configuration	Closed (3 wires) or open (6 wires) delta Star without Neutral (3 wires) or with Neutral (4 wires) Load type and assembly configuration using jumpers.

Control

Supply voltage	**100 V** to **240 V** (+10%; -15%) Consumption: **20 VA** (add 25 VA par fan)
Thyristor firing modes	• **On / Off** (Logic) • **Burst firing** (number of firing times adjustable between **1** and **255** supply cycles). For **these two** modes: - start at **zero voltage** for resistive loads with elimination of the DC component - start at **zero current** on each phase for inductive loads with **elimination** of transient currents (setting using potentiometer on front panel) - possibility of adjustable **soft** start and (or) end between **1 and 255** supply cycles for the start and end of each firing cycle (thyristor firing angle variation) - selectable initial ramp in Phase angle (32 supply cycles). • **Phase angle** Possibility of **soft** start and (or) end with a **linear ramp** on a setpoint change (increase/decrease), the duration of the ramp from 0 to 100% firing is **0.1 s** to **40 H** (setting using potentiometer on front panel).
Control signal	**Analogue :** Voltage: **0-5 V**; **1-5 V**; **0-10 V** or **2-10 V** Input impedance ≥100 kΩ Current: **0-20 mA**; **4-20 mA** Input impedance 100 Ω Second input with low win action **Logic :** On ≥ **50%** of the configuration input signal Off ≤ **25%** of the configuration input signal
Control mode	• Squared load voltage **V ²** • External measurement • Open loop
Control quality	**Linearity** : **±1%** in Phase angle; **±2%** in Burst firing **Stability** : **±1%** in Phase angle; **±2%** in Burst firing with variations: - of the power supply voltage +10%, -15%; - of the temperature 0 to 50 °C Adjustable **response time**. To change from **10%** to **90%** power: - in Phase angle - **120 ms** to **1.5 s** - in Burst firing - **0.3 s** to **150 s**
Retransmissions	Outputs (**0** to **10 V**) of the **controlled parameter** (DC signal).

Alarms and Monitoring

Voltage alarms	• Absence of power supply voltage on any phase • Under-voltage (thyristor firing stopped below 7**0%** or 50% of the nominal thyristor unit voltage) • Over-voltage (alarm for a voltage greater than the nominal thyristor unit voltage by **20%**)
Frequency alarm	Above **70 Hz** or below **40 Hz**
Monitoring	**Permanent data** on the alarm type and its degree of severity with a **display** and with **relays**
Diagnostics	Socket for diagnostic unit used to adjust, control and calibrate the thyristor unit **locally** using **20 test signals**
Retransmissions	Outputs of the **controlled parameter** (**0** to **10 Vdc**)

Environment

Operating temperature	**0°C** to **+50°C** (40°C for 500 A; at 50°C rated at 450 A)
Altitude	Maximum **2000 m**
Storage temperature	**-10°C** to **+70°C**
Thyristor protection	Internal high speed **fuses. Varistor** and **RC** snubber
Protection	**IP20** on front panel (according to Standards **IEC 529**)
External wiring	To be performed according to the Standards **IEC 364**
Operating environment	Non-explosive, non-corrosive and non-conductive
Humidity	RH from **5**% to **95%** without condensation
Pollution	Degree **2** admissible, defined by **IEC 664**
Dimensions (25 A to 250 A)	**480 mm** (H) x **248 mm** (W) x **268 mm** (D) Weight **16 kg**, (250 A : **18 kg**)
(300 A to 500 A)	**570 mm** (H) x **373 mm** (W) x **268 mm** (D). Weight **21 kg.**
Electromagnetic compatibility (The TC3000 installed and used in accordance with User Manual, see European Directives chapter)	**Immunity** : comply with Standards **EN 61000-4-2, EN 61000-4-4, EN 61000-4-3** **Radiated emission** : comply with **EN 55011** **Conducted emission** : comply with **EN 50081-2** (without external filter in Burst firing on resistive load; with an external filter for other configurations), comply with **EN 61800-3** (without external filter).
Electrical safety	Comply with **Low Voltag Directive 73/23/EEC**
CE Mark	The TC3000 products are **CE marked** (see European Directives chapter).

Caution !

Due to the continual improvement of products, Eurotherm may be required to modify specifications without prior notice. For any further information and in the event of doubt, contact your Eurotherm Office.

CODING

TC3000 /	Nominal current /	Line voltage /	Auxiliary power supply /	Operating voltage (calibration) /	Input signal

Nominal current	Code
25 amperes	**25A**
40 amperes	**40A**
60 amperes	**60A**
75 amperes	**75A**
100 amperes	**100A**
150 amperes	**150A**
250 amperes	**250A**
300 amperes	**300A**
400 amperes	**400A**
500 amperes	**500A**

Operating voltage	Code
100 volts	**100**
110 volts	**110**
115 volts	**115**
120 volts	**120**
200 volts	**200**
220 volts	**220**
230 volts	**230**
240 volts	**240**
277 volts	**277**
380 volts	**380**
400 volts	**400**
415 volts	**415**
440 volts	**440**
480 volts	**480**
500 volts	**500**

Line voltage	Code
240 volts	**240V**
440 volts	**440V**
480 volts	**480V**
500 volts	**500V**

Input signal	Code
0-5 volts	**0V5**
1-5 volts	**1V5**
0-10 volts	**0V10**
2-10 volts	**2V10**
0-20 mA	**0mA20**
4-20 mA	**4mA20**

For other voltages, contact your Eurotherm Office

Auxiliary power supply	Code
110 volts	**100V**
110 to 120 volts	**110V120**
200 volts	**200V**
220 to 240 volts	**220V240**

Thyristor firing mode	/	Ramp, soft start, end	/	Load connection	/	Load type	/	Controlled parameter	/	Auxiliary input-output	/	Options	/	00

Thyristor firing mode	Code
Logic (ON/OFF)	**LGC**
Phase angle	**PA**
Burst firing:	
1 supply cycle	**FC1**
2 supply cycles	**FC2**
4 supply cycles	**FC4**
8 supply cycles	**FC8**
16 supply cycles	**C16**
32 supply cycles	**C32**
64 supply cycles	**C64**
128 supply cycles	**128**
255 supply cycles	**255**

Ramp, soft start/end	Code
Without ramp and without soft start/end	**NRP**
Positive ramp or soft start	**URP**
Positive and negative ramps or soft start/end	**UDR**

Load connection	Code
Delta (3 wires)	**3D**
Star without neutral (3 wires)	**3S**
Star with neutral (4 wires)	**4S**
Open delta (6 wires)	**6D**

Load type	Code
Inductive	**IND**
Other loads	**RES**

Controlled parameter	Code
External (See Auxiliary input)	**EX**
Squared load voltage	**V2**
Open loop	**OL**

Auxiliary input/output		Code
Controlled parameter retransmission		**RTR**
External control (if controlled parameter **EX**)	0-5 V	**E0V5**
	1-5 V	**E1V5**
	0-10 V	**E0V10**
	2-10 V	**E2V10**
	0-20 mA	**E0mA20**
	4-20 mA	**E4mA20**
Second setpoint	0-5 V	**W0V5**
	1-5 V	**W1V5**
	0-10 V	**W0V10**
	2-10 V	**W2V10**
	0-20 mA	**W0mA20**
	4-20 mA	**W4mA20**

Options	Code
Alarm relay contact closed in alarm state	**IPU**
Fuse blown indication micro-switch	**FUMS**
Without internal fuses	**NOFUSE**

Simplified or complete coding

Coding can be performed with a **complete code** (all fields) or with a **simplified code** in which **only** the following are specified:

- the nominal current,
- the line voltage,
- the auxiliary power supply,
- the calibration voltage (operating voltage),
- the options.

With a **simplified code,** the **TC3000** thyristor unit is supplied **configured** as shown below:

• Input signal	4 - 20 mA
• Thyristor firing mode	Phase angle
• Ramp, soft start / end	Without ramp or soft start / end
• Load connection	Star without neutral (3 wires)
• Load type	Inductive
• Under-voltage alarm threshold	70% of nominal voltage
• Start-up	Initial safety ramp (32 supply cycles)

Coding example

Thyristor unit and installation parameters

Nominal load current	**120 amperes**
Nominal power supply voltage	**440 volts (line-to-line)**
Auxiliary power supply	**220** to **240 volts**
Calibration voltage	Installation at **380 volts**
Input signal	**0 - 10 volts**
Firing mode	**8 cycle** burst firing with soft **start**
Connected loads	**Resistive**
Connection type	**Star without neutral**
Controlled parameter	**Load voltage**
Auxiliary input / output	**Controlled parameter** retransmission
Option	Fuse blown indication **micro-switch**

Coding:

TC3000/150A/440V/220V240/380/0V10/FC8/URP/3S/RES/V2/RTR/FUMS/00

Caution !

The TC3000 thyristor unit operating voltage must be as close as possible to the power supply voltage to prevent problems of non-operation in the event of a voltage drop to less than **70 %** of the nominal voltage (after calibration).

The **calibration** voltage (the operating voltage) is considered as the **nominal voltage** of the thyristor unit.

SERIAL NUMBER LABELS

Two **identification** labels (specifying the **coding** of the thyristor unit) and a **configuration** label provide all the information relating to the factory settings of the thyristor unit.

An identification label is **externally** located on the right-hand side panel of the unit.

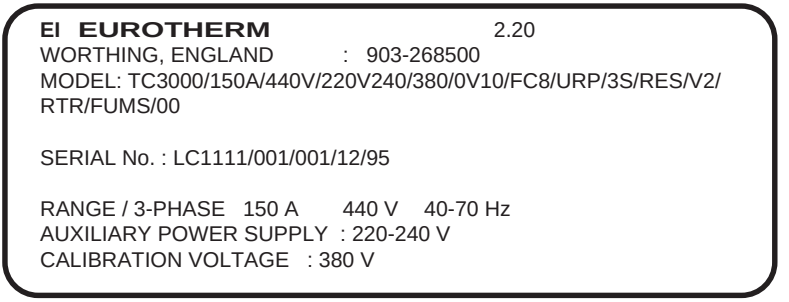
EI EUROTHERM 2.20
WORTHING, ENGLAND : 903-268500
MODEL: TC3000/150A/440V/220V240/380/0V10/FC8/URP/3S/RES/V2/
RTR/FUMS/00
SERIAL No. : LC1111/001/001/12/95
RANGE / 3-PHASE 150 A 440 V 40-70 Hz
AUXILIARY POWER SUPPLY : 220-240 V
CALIBRATION VOLTAGE : 380 V

Figure 1.3 Example of identification label for a TC3000 thyristor unit
The information corresponds to the coding example

The second identification label and a configuration label are located **inside** the thyristor unit.

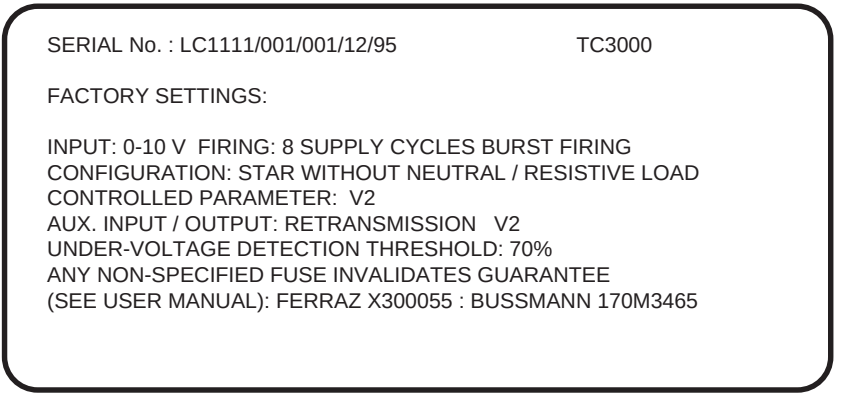
SERIAL No. : LC1111/001/001/12/95 TC3000
FACTORY SETTINGS:
INPUT: 0-10 V FIRING: 8 SUPPLY CYCLES BURST FIRING
CONFIGURATION: STAR WITHOUT NEUTRAL / RESISTIVE LOAD
CONTROLLED PARAMETER: V2
AUX. INPUT / OUTPUT: RETRANSMISSION V2
UNDER-VOLTAGE DETECTION THRESHOLD: 70%
ANY NON-SPECIFIED FUSE INVALIDATES GUARANTEE
(SEE USER MANUAL): FERRAZ X300055 : BUSSMANN 170M3465

Figure 1.4 Example of configuration label for a TC3000 thyristor unit

Caution !

Any reconfiguration done by the user will render obsolete the original in-house configuration code shown on the label.

Chapter 2

INSTALLATION

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Chapter 2 INSTALLATION

SAFETY DURING INSTALLATION

Warning !

TC3000 units must be installed by a person qualified and authorised to work in an industrial low voltage electrical environment.

Units must be installed in correctly fan-cooled electric cabinets, guaranteeing the absence of condensation and pollution.
The cabinet must be closed and connected to the safety earth in accordance with the standard IEC 364 or the current national standards.

For installations in fan-cooled cabinets, it is recommended to place a fan failure detection device or a thermal safety control in the cabinet.

Bulkhead mountings are possible with **TC3000** series units.

The units must be mounted with the heatsink positioned vertically and with no obstructions either above or below which could block the passage of the ventilation air.

If multiple units are installed in the same cabinet, they should be arranged in such a way way that the exhaust air from one unit cannot be admitted into the unit located above it.

Caution !

The units are designed to be used at an ambient temperature less than or equal to **50°C** (40°C for 500 A nominal units).

Leave a minimum space of **20 cm** between two units placed beside each other.

Excessive overheating may cause incorrect operation of the unit, which in turn may cause damage in the components.

TC3000 series power thyristor units have **permanent** fan cooling from **100 A** nominal.

DIMENSIONS

The overall dimensions of TC3000 thyristor units are given in figure 2-1.

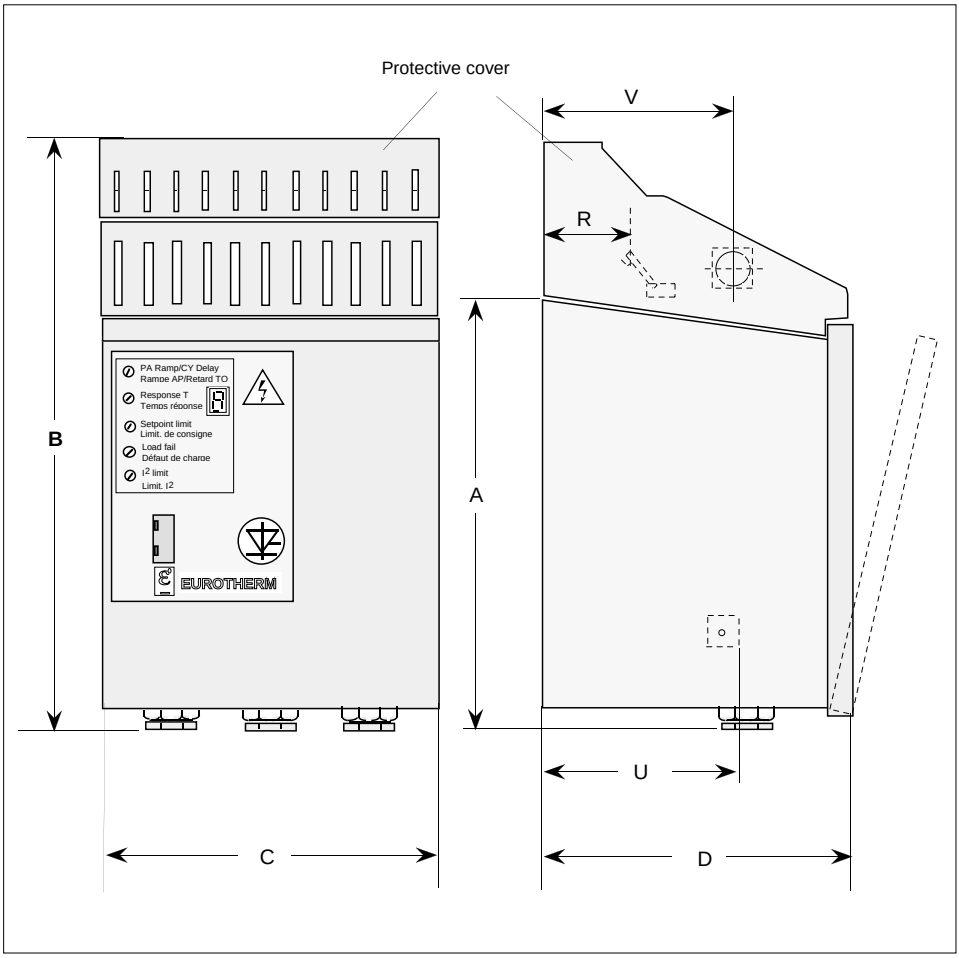

Figure 2-1 TC3000 thyristor unit values

The dimensions and weights of the **TC3000** thyristor unit are given in tables 2-1 and 2-2.

Values (fig.2-1)	Dimensions (mm) Nominal thyristor unit current 25 to 150A	250A	300 to 500 A	Description
A	425	425	425	Height without protective cover
B	480	480	570	Height with protective cover
C	248	248	373	Width
D	268	268	268	Depth (with door open: 537 mm)
R	50	50	20	Distance between 'Earth' busbar and panel
U	150	125	150	Depth between 'LOAD' terminal and panel
V	145	145	170	Depth between 'LINE' terminal and panel

Table 2-1 TC3000 thyristor unit dimensions

Nominal thyristor unit current	25 to 150 A	250 A	300 to 500 A
Weight (kg)	16	18	21

Table 2-2 TC3000 thyristor unit weights

INSTALLATION DETAILS

TC 3000 series units are designed to be mounted directly on panels at the fixing points located on the rear of the unit.
TC 3000 thyristor units are equipped with two protective covers (upper and lower).

The thyristor units can be fixed with their protective covers in place.
However, for configuration, the upper protective cover must be removed.
In order to do this, open the door by unfastening the front screw located at the top left of the door. Then raise the door in order to release it from its notches and open it completely by pulling it towards you.

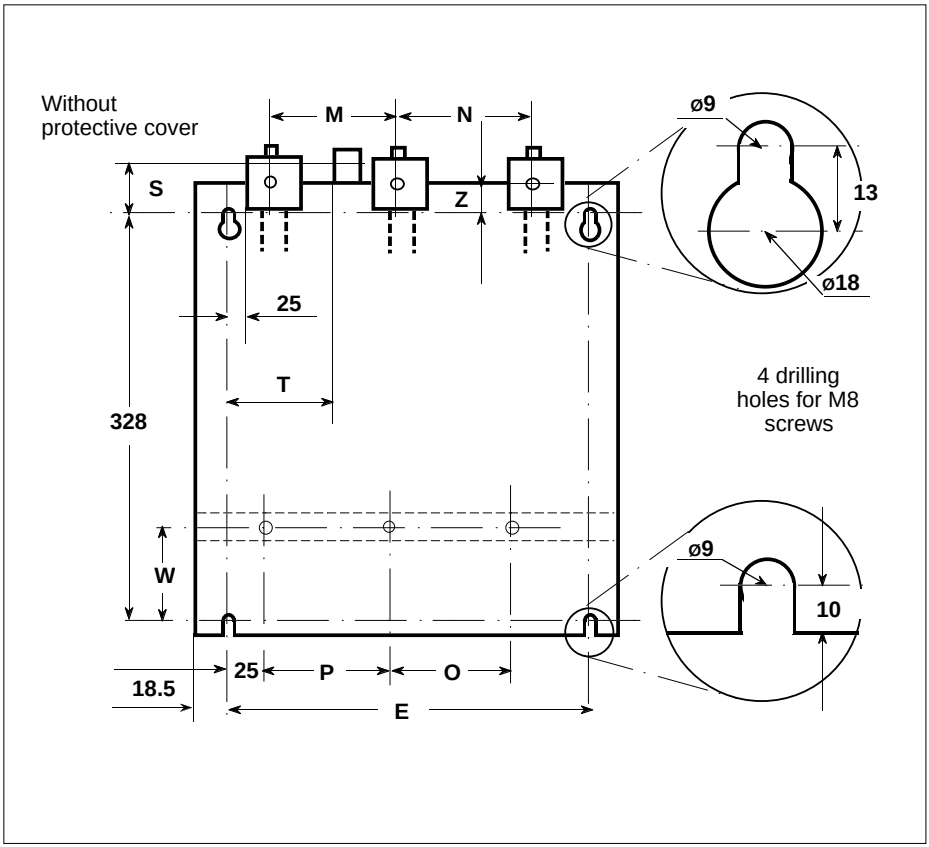

Figure 2-2 Fixing details

Values fig.2-2	Dimensions (mm) Nominal current 25A to 150A	250A	300A to 500A	Description
E	203	203	328	Width between the fixing holes
M and N	75	75	112	Distance between the 'LINE' terminals
O and P	75	75	112	Distance between the 'LOAD' terminals
S	60	60	30	'Earth' busbar and top fixing hole
T	65	65	220	'Earth' busbar and left fixing hole
W	70	85	70	'LOAD' terminal and bottom fixing hole
Z	40	50	30	'LINE' fuse and top fixing hole

Table 2-3 Fixing values

After drilling the support panel at the dimensions and values given above, insert the fixing screws half-way into the partition or mounting plate holes.

Position the **TC3000** unit by first of all inserting the upper screws in the respective holes of the upper section.

Lower the thyristor unit making sure that it is positioned correctly at the level of the lower screws.

Then lower the thyristor unit completely until it is in place.
Fasten the **4 screws** correctly.

Chapter 3

WIRING

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Chapter 3 WIRING

SAFETY DURING WIRING

Warning !

Wiring must be performed by personnel who are qualified to work with low voltage electrical equipment.
It is the user's responsibility to wire and protect the installation in accordance with current professional standards.
A suitable device guaranteeing electrical separation of the equipment and the power supply must be installed upstream from the unit in order to perform the operation in complete safety.

TC3000 series units possess **two protective covers**: upper and lower.
The upper cover should be raised to facilitate wiring.
After connection and before power-up, put the upper protective cover back in place to ensure the specified **degree of protection**.

Warning !

Before any connection or disconnection, make sure that the power and control cables and wires are isolated from the voltage sources.
For safety reasons, the safety earth cable must be connected before any other connection during wiring and the last cable to be disconnected.

The **safety earth** is connected to the screw located on the busbar provided for this purpose in the top part of the unit, behind the phase terminal and labelled as follows:

Caution !

To ensure the correct grounding of the TC3000 unit, make sure that the fixing is on the **reference ground surface** (panel or bulkhead).
Failing this, it is necessary to add a ground connection at **most 10 cm** long between the earth connection and the reference ground surface.

Warning !

This connection which is intended to ensure good **ground conductivity**, **can never** be used to **replace** the **safety earth** connection.

The power terminal capacities are given in table 3-1.

The **tightening torques** must observe the limit values in the same table.

Nominal current	**25 A to 150 A**	**250 A**	**300 A to 500 A**
Power supply and load cables	4 to 70 mm^2	120 mm^2	185 to 2x150 mm^2
Safety earth cable	14 to 35 mm^2	64 mm^2	95 to 185 mm^2
Fuse terminals	M8	M8	M10
Tightening torque	12.5 N.m	12.5 N.m	25 N.m
Load screw	M10	M10	M12
Tightening torque	25 N.m	25 N.m	28.8 N.m
Cable sheath passage diameter	20 mm	34 mm	38 mm

Table3- 1 TC3000 thyristor unit power wiring details

The cross-section of the connection wires to be used must comply with the Standard **IEC 943**.

The power cables to the load should pass through **cable sheaths**.
These must be **tightened** as much as possible after the passage of the cables.

The cable sheath **passage** diameter is given in table 3-1.

Important !

For loads composed of 3 primary transformer coils, the coil connection **direction** must be observed.

POWER WIRING DIAGRAMS

The TC3000 power wiring diagram depends on the load configuration.

Four **power** and **safety earth** wiring diagrams are given below for the different types of load configuration.

Star without neutral configuration

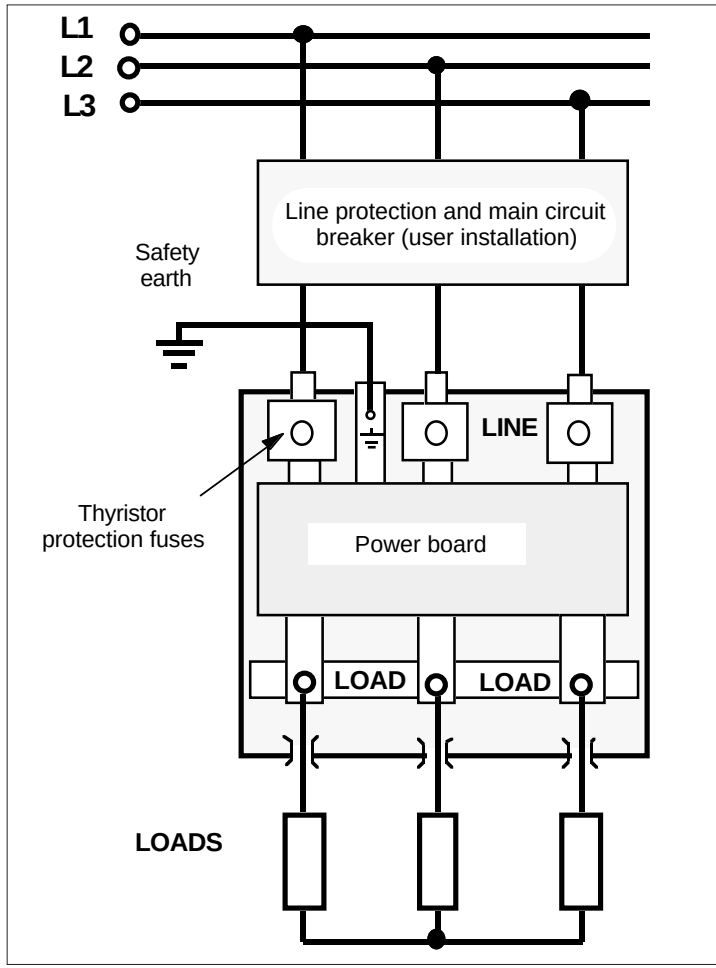

Figure 3-1 Power and safety earth wiring diagram for a load connected in 'Star without neutral' (3 wires)

Star with neutral configuration

If the load is wired in 'Star with Neutral' (4 wires), **the neutral must also be connected** to the neutral terminal block (terminal **71**) below the thyristor unit.

In the 'Phase angle' firing mode, the neutral current contains the sum of the 3rd harmonics of each phase. For small firing angles (less than 100°), the current passing in the neutral of the loads can be up to **25% greater** than the line current in full firing.

Caution !

This current requires an adapted design of the neutral cable, especially for loads composed of short wave infrared elements.

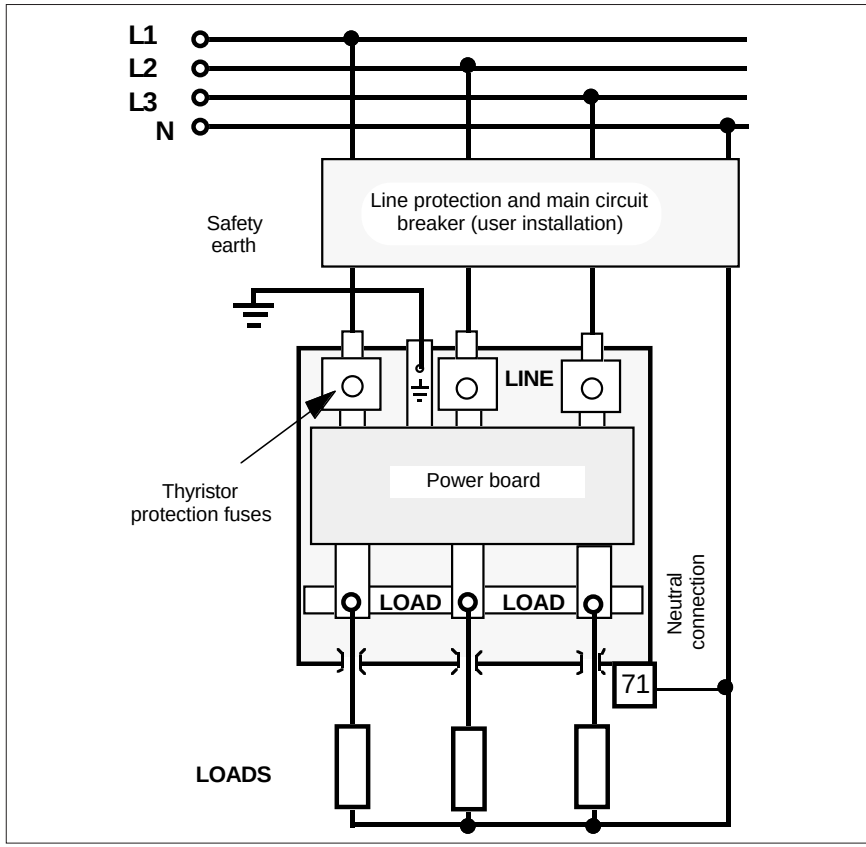

Figure 3-2 Power, safety earth and neutral wiring diagram for a load connected in 'Star with neutral' (4 wires)

Closed delta configuration

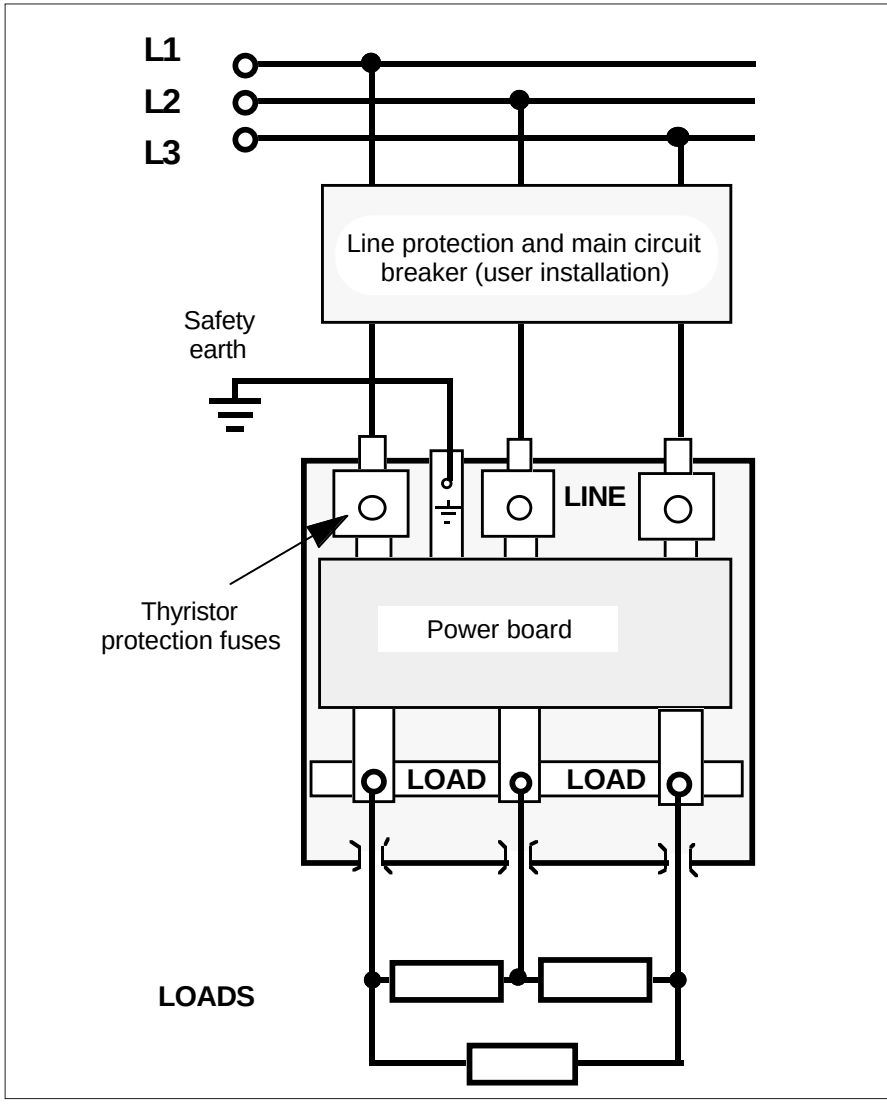

Figure 3-3 Power and safety earth wiring diagram for a load connected in 'Closed delta' (3 wires)

Open delta configuration

Important !

The load wiring diagram given below must be observed.

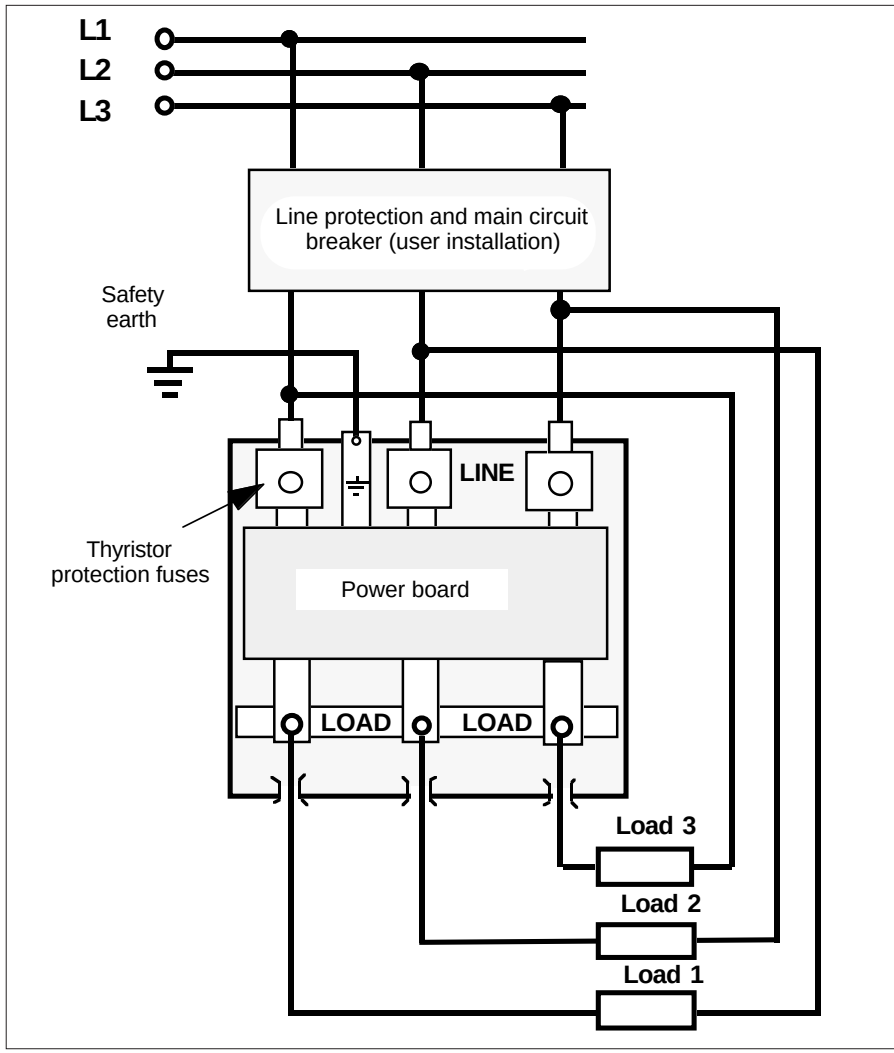

Figure 3-4 Power and safety earth wiring diagram for a load connected in 'Open delta' (6 wires)

USER TERMINAL BLOCKS

General introduction

The user terminal blocks, located below the **TC3000** thyristor units, are intended for the following connections:

- the auxiliary power supply,
- the reference neutral,
- the alarm relay contact.

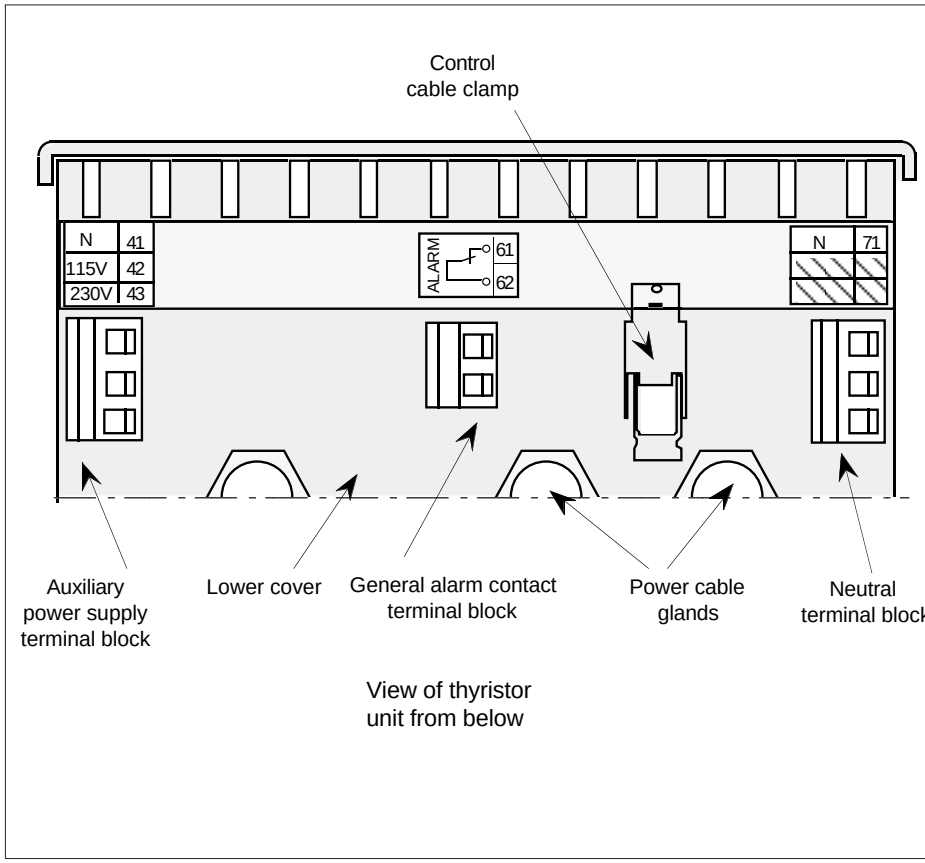

Figure 3-5 User terminal blocks

Terminal numbers	Destination
41 42 43	Auxiliary power supply: Neutral 115 V (single-phase supply) 230 V (single-phase or three-phase-line-to-line supplies)
61, 62	General alarm relay contact: Contact open in alarm state (**standard**) Contact closed in alarm state (**IPF option**)
71	Reference neutral (only in 'Star with neutral' load configuration).

Table 3-2 Destination of user terminal block terminals

The max. cross-section of the low level wires and cables is **1.5 mm²**.

Tightening: **0.7 N.m.**

Auxiliary power supply

The 'Auxiliary power supply' user terminal block supplies power to the electronics (for units from **100 A**) and the fans.
The terminal block is located to the left below the thyristor unit.
The electronics earth is connected (inside the thyristor unit) with the earth of the power section.

The auxiliary power supply neutral wire is connected to terminal **41**.

The auxiliary power supply must be connected to a **115V** or to a **230V**.

Terminal **42** is used if the auxiliary power supply voltage is **115V**
(auxiliary power supply codes **100V** to **120V**).

Terminal **43** of the user terminal block is used if the auxiliary power supply voltage is **230V**
(auxiliary power supply codes **200V** to **240V**).

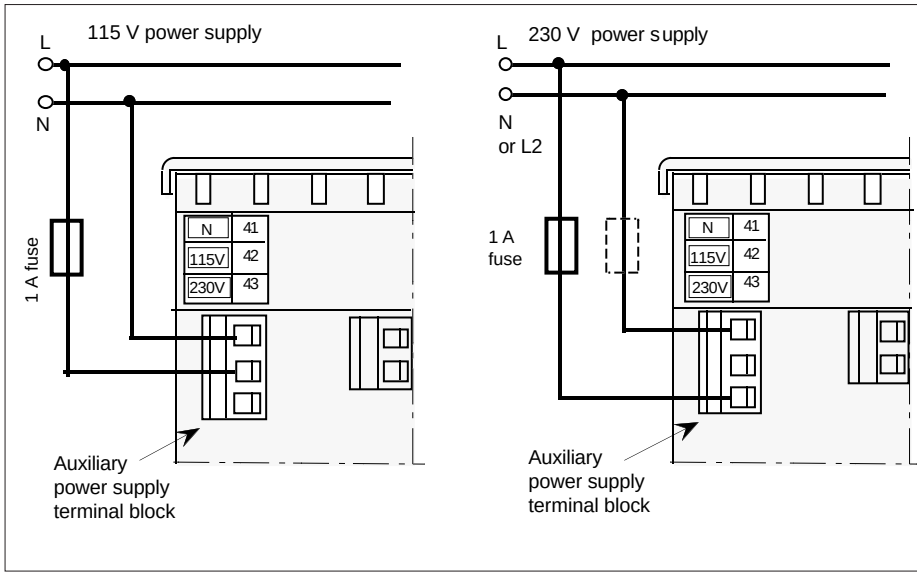

Figure 3-6 Auxiliary power supply connection

Caution !

Each wire to a power supply phase must be protected with a 1 A fuse.

Reference neutral

The reference neutral is connected to terminal **71** located on the neutral terminal block to the right below the thyristor unit (see figure 3-5).

Caution !

This connection is only made for the star with neutral load configuration.

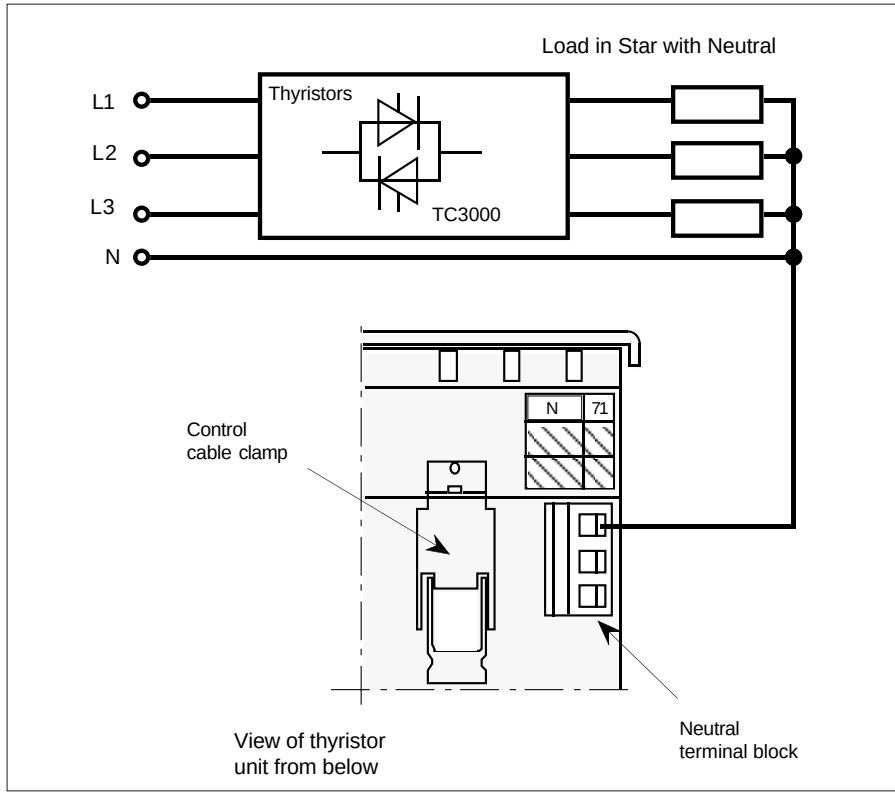

Figure 3-7 Neutral connection

In the event of a neutral connection failure (incorrect electrical connection, blow-out of **F1** fuse on the power board, etc.), an **artificial power failure** is created in order to **stop** the thyristor unit operation, since the feedback system receives an incorrect feedback signal.

This failure is signalled with the message '**FP**' on the front panel display.

Alarm contacts

The TC3000 thyristor units are equipped with a general alarm relay (see 'Alarms' chapter).

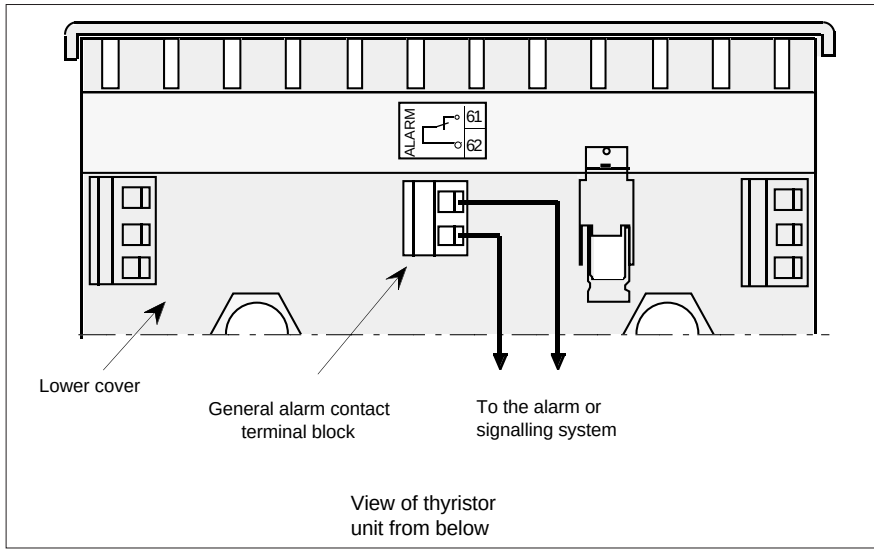

Figure 3-8 General alarm and PLF contact connection (view from below)

The alarm relay contact output is provided on the user terminal blocks below the thyristor unit and is available without opening the front door.

Important

The relay contact is protected against interference by internal RC snubbers.

The type of contact specifying the alarm state is determined by the thyristor unit coding.

Alarm type	Terminals	Contact type	Coding
General alarms	61, 62	N/O open in alarm state	Standard
		N/C closed in alarm state	IPU

Table 3-3 Destination of alarm contact terminals

CONTROL CABLES

Caution !

The control connections must be made with **shielded cables connected to the earth at both ends** in order to ensure satisfactory immunity against interference.

Separate the control cables from the power cables in the cable trays.

Fixing

The control wires must be grouped together in a shielded cable passing through the **cable clamp** under the unit.

To facilitate the safety earthing of the cable shield and to ensure maximum immunity to electromagnetic interference, the metal cable clamp is connected directly to the ground of the **TC3000** thyristor unit.

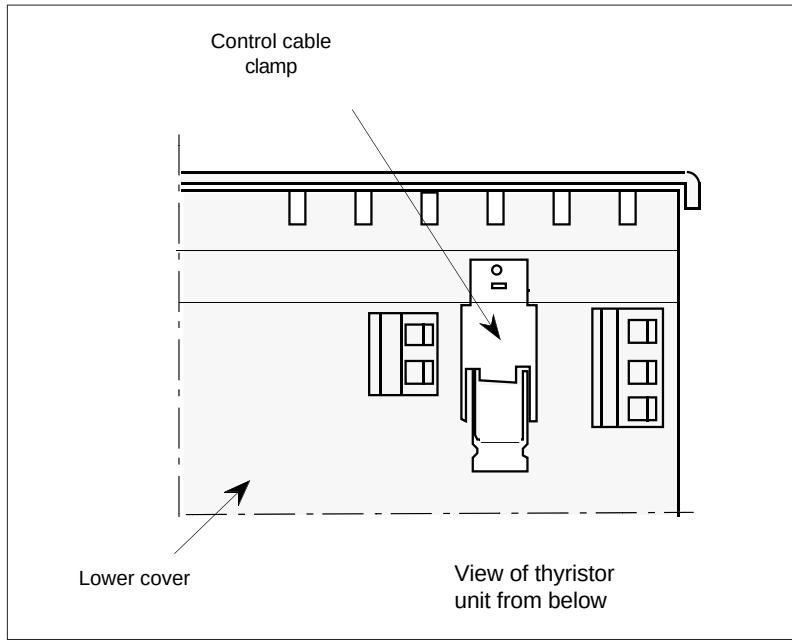

Figure 3-9 Control cable fixing

Connection of the shield to the ground

• **Strip** the shielded cable as shown in figure 3-10,a.

The control wires must be long enough for the connection between the metal cable clamp and the driver board user terminal blocks, with the door open.
The wiring inside the unit must be as short as possible.

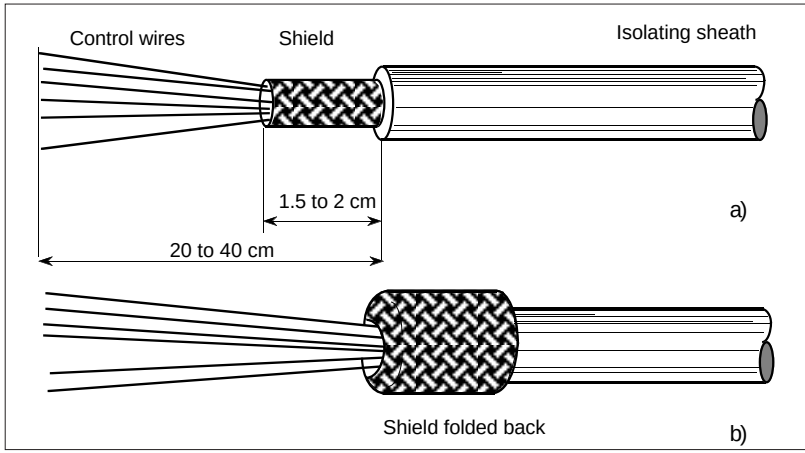

Figure 3-10 Control cable stripping

• **Fold back** the shield on the isolating sheath (figure 3-10,b)
• **Insert** the cable in the metal cable clamp so that the shield is located in the stirrup and does not enter the unit (it must not pass the lower cover).
• **Tighten** the stirrup (**4 x 1** flat screwdriver; tightening: **0.7 N.m.)**.

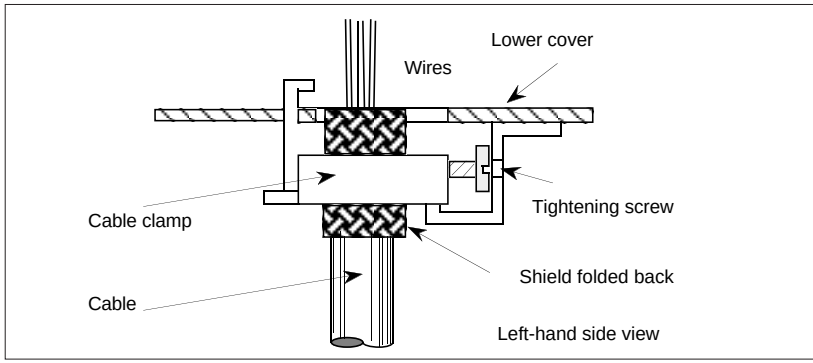

Figure 3-11 Cable tightening and shield grounding

The possible cable **diameters** with the shield folded back are **5 to 10 mm** per cable clamp.

CONTROL TERMINAL BLOCKS

The control wires are connected on the **driver board** for:

- the control setpoint connection
- the retransmissions of the voltage and controlled parameter indications.

Caution !

For electromagnetic compatibility reasons, the connection must be made with shielded cables and wires which are shielded and earthed (or grounded) at both ends.

Control terminal tightening: **0.7 N.m.**

The driver board terminal blocks can be accessed with **the front door open.**
To open the door, unfasten the front **screw**, release the door from its notches by raising it and pull it towards you.

Warning !

With the door open, dangerous live parts may be accessible if the **TC3000** thyristor unit supply is switched on.

General introduction

Two user terminal blocks are located in the top right corner of the driver board.

The **'Control'** terminal block (**H12)** contains **7** terminals labelled **11 to 17**.

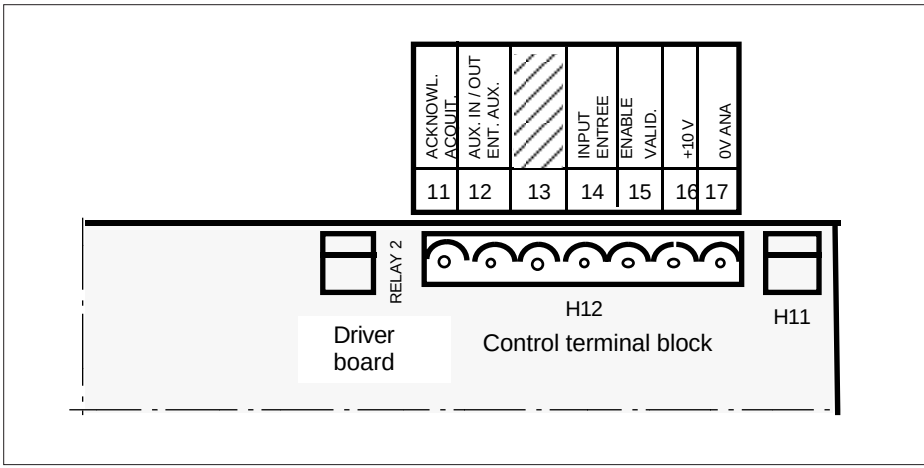

Figure 3-12 Driver board terminal blocks

Terminal	Designation on label	Destination
11	ACKNOWL. / ACQUIT.	Alarm acknowledge
12	AUX. IN/OUT ENT. AUX.	External feedback or retransmission of controlled parameter
13	---	Not used
14	INPUT / ENTREE	Control input
15	ENABLE / VALID.	Enables thyristor unit operation
16	+10 V	+10 V
17	0 V ANA	0 V of analogue signals

Table 3-4 Control terminal block description

For the correct operation of the thyristor unit, terminal **15** ('**ENABLE**') must be connected to **'+10 V'** available on the same terminal block (terminal **16)**.
This connection can be permanent or made via a contact opening under the effect of a device used to inhibit the thyristor unit (during the next half-period).

External control input

The external control signal (external analogue setpoint or logic signal) is connected to the control terminal block on the driver board, between terminal **14** ('**INPUT**') and terminal **17** ('**0 V ANA**'). The input signal is jumper configurable.

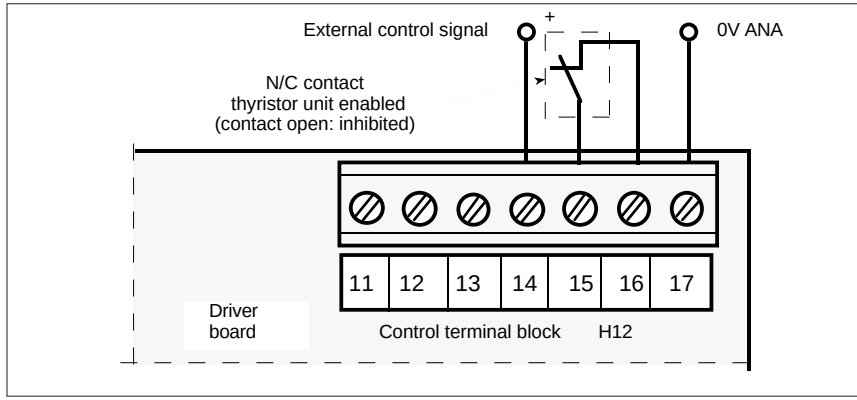

Figure 3-13 External control connection

Manual control

The thyristor unit can be driven using the manual control.
For operation with the manual control, a **4.7 kΩ** to **10 kΩ** external potentiometer connected between terminals **17** ('**0 V ANA**') and **16** ('**+10 V**') must be used.
The potentiometer wiper is connected to the control terminal block analogue input (terminal **14**).
The manual input signal must be configurated in **0 - 10 V**.

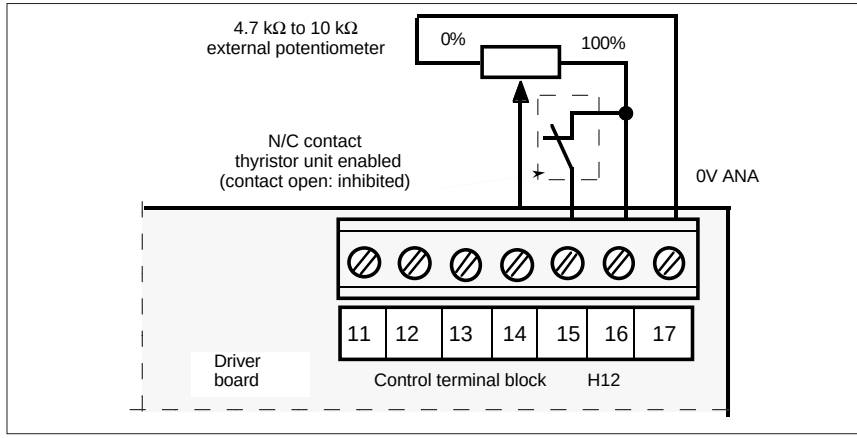

Figure 3-14 Manual control connection using an external potentiometer

Auxiliary input / output

The auxiliary input / output (terminal **12** - '**AUX. IN/OUT**' on the Control terminal block) is depending on the configuration:

- the controlled parameter (output)
- the external feedback (input)
- the second analogue setpoint (input).

If **retransmission** of the controlled parameter has been configured, the internal feedback signal is available between terminals **17** ('**0 V ANA**') and **12** in the form of a DC signal with a scale **0-10V**. This retransmission represents the squared RMS load voltage.

If **external measurement** control is selected, the external feedback signal must be connected between terminals **17** and **12**.

If a **low-win selector** type feedback is selected, the second setpoint must be connected between terminals **12** and **17**. The **TC3000** thyristor unit then controls **the lower** of the 2 control signals.

Terminals **15** and **16** of the control terminal block are connected to enable the thyristor unit.

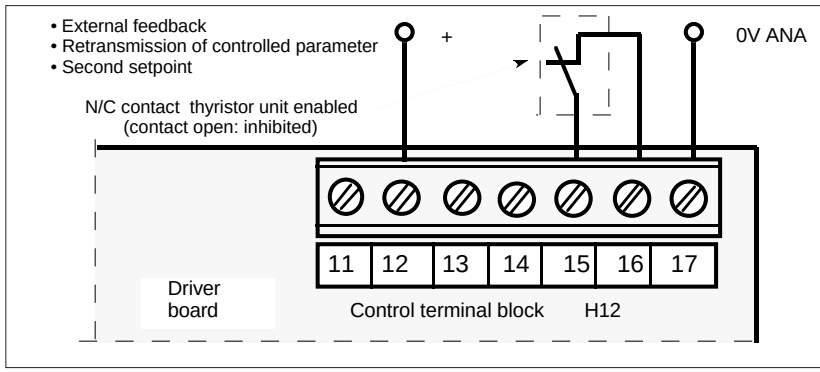

Figure 3-15 Auxiliary signal (input or output) connection

Alarm acknowledge

After the cause of certain alarms has disappeared (see 'Alarms' chapter), it is necessary to acknowledge the memorised alarm to return to normal thyristor unit operation.

The alarm is acknowledged by connecting terminal **11** ('**ACKNOWL.**') on the control terminal block to '**+ 10 V**' (terminal **16**) or to the external +10 volts with the common 0 V.

Chapter 4

CONFIGURATION

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Chapter 4 CONFIGURATION

SAFETY DURING CONFIGURATION

The thyristor unit is configured in the factory using moveable **jumpers** and soldered **links**. The thyristor unit can be **reconfigured** on site using **jumpers**.

Important !

The thyristor unit is supplied fully configured in accordance with the code on the identification label.

This chapter is included in order to

- **check** that the configuration is compatible with the application
- **modify,** if necessary, certain characteristics of the thyristor unit on-site.

Warning !

For safety reasons, the reconfiguration of the thyristor unit using jumpers must be performed with the unit **switched off** and by qualified personnel authorised to work in an industrial low voltage electrical environment.

Before starting the reconfiguration procedure, check that the thyristor unit is isolated and that an occasional power-up is impossible.

After the reconfiguration of the unit, correct the codes on the identification label to prevent any maintenance problems later.

POWER BOARD

The power board jumpers are used to configure:

- the three-phase voltage selection for synchronisation and measurement
- the adaptation to the load connection type.

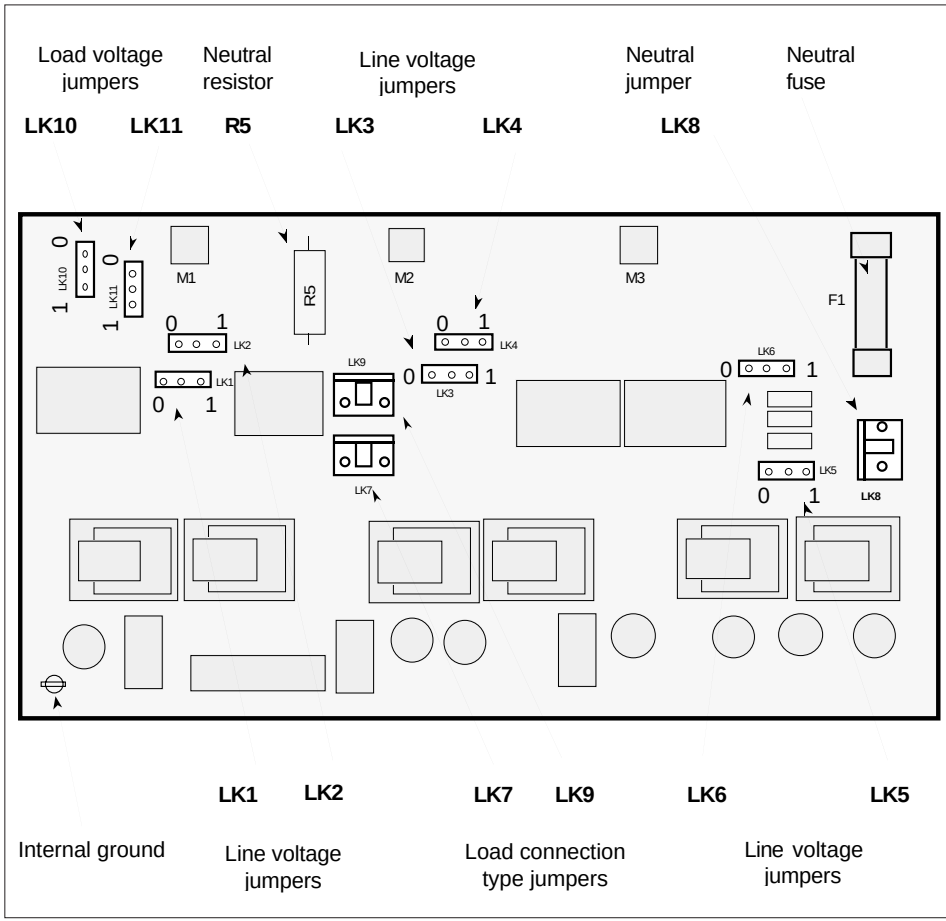

Figure 4-1 Location of jumpers on the power board

Voltage selection

For the synchronisation of operation of the electronics and for measurement, the **TC3000** thyristor unit operation voltage must be configured according to the power supply voltage on which it is connected.

Operation of a **TC3000** thyristor unit on a power supply voltage **different** to that specified on the order, may require the repositioning of jumpers **LK1** to **LK6** (three-phase line voltage) and **LK10** and **LK11** (load voltage) on the power board.

For some applications (perturbed supply with over-voltages transient for instance) TC3000 line voltage can be chosen higher their operating voltage.

Operating voltage less than or equal to	**Position of jumpers**	
	LK1, LK3, LK5 and LK10	**LK2, LK4, LK6 and LK11**
100, 110, 115 , 120 V	1	1
200, 220, 230, 240 V	1	0
380, 400, 415, 440 V	0	1
480, 500 V	0	0

Table 4-1 Line voltage and load voltage configuration

Caution !

Do not use a thyristor unit with a power supply voltage higher than the power supply voltage specified for the thyristor unit.

Adaptation to the load configuration type

A thyristor unit is configured according to the load configuration type using jumpers **LK7** to **LK9** on the power board and using jumpers **K5** and **K6** on the driver board (see page 4-12).

Caution !

It is necessary to check that the position of jumpers LK7 to LK9 (table 4-2) corresponds to the position of jumpers K5 and K6 (table 4-11).

Load configuration	Code	Position of jumpers on power board		
		LK7	LK8	LK9
Star without neutral (3 wires)	3S	Jumper	Open	Open
Star with neutral (4 wires) Connection of the neutral wire to the user terminal block below the thyristor unit	4S	Open	Jumper	Open
Closed delta (3 wires)	3D	Jumper	Open	Open
Open delta (6 wires)	6D	Open	Open	Jumper

Table 4-2 Load connection type configuration

For the star with neutral configuration (**4S** code) the neutral resistor **is fitted** on the power board (**R5** see figure 4-1). The R5 value depends of unit voltage.
For **other** configurations (3S, 3D, 6D codes) the R5 is **not fitted**.

Caution !

The factory configurated unit for 3 or 6 wires, can be reconfigurated to star with neutral according to table 4-2, but this **requires to fit R5** resistor on power board.

For this reconfuguration or for in case of operating voltage change, the resistor **R5** (**3 W**) has to be ordered according to following part numbers:

CZ 17498810K for 120 V max (10 kΩ);
CZ 17498827K for 240 V max (27 kΩ);
CZ 17498833K for 440 V max (33 kΩ);
CZ 17498856K for 500 V max (56 kΩ).

DRIVER BOARD

The driver board jumpers are used to configure:

- the auxiliary power supply,
- the control signals,
- the thyristor firing mode,
- the load configuration type,
- the operation type,
- the alarm relay contact type.

The functions of the driver board jumpers are summarised in the table below.

Function	Jumpers	Configuration see page
	Soldered links	
Auxiliary power supply	LK1 and LK2	4-8
Main setpoint signals	J11 to J15	4-9
Auxiliary input or output	J36 and SW1	4-10
Auxiliary input/output type	J31 to J35	4-10
Thyristor firing mode	K1 and K2	4-11
Setpoint change ramp action		
or soft start/end	K3 and K4	4-11
Load configuration type	K5 and K6	4-12
Load type	K7	4-12
Controlled parameter	K8 and K9	4-9
Second setpoint action	K10	4-10
Relay contact type	VX2	4-12
Calibration / Operation	M1	4-13
Initial ramp	K12	4-14
Under-voltage alarm level	K11	4-13

Table 4-3 Driver board jumper functions

The position of the jumpers **S1** and **S2, M2** to **M3** and **J21** to **J25** is not important in this version of the thyristor unit.
The jumper **K13** must always be set to **0**.

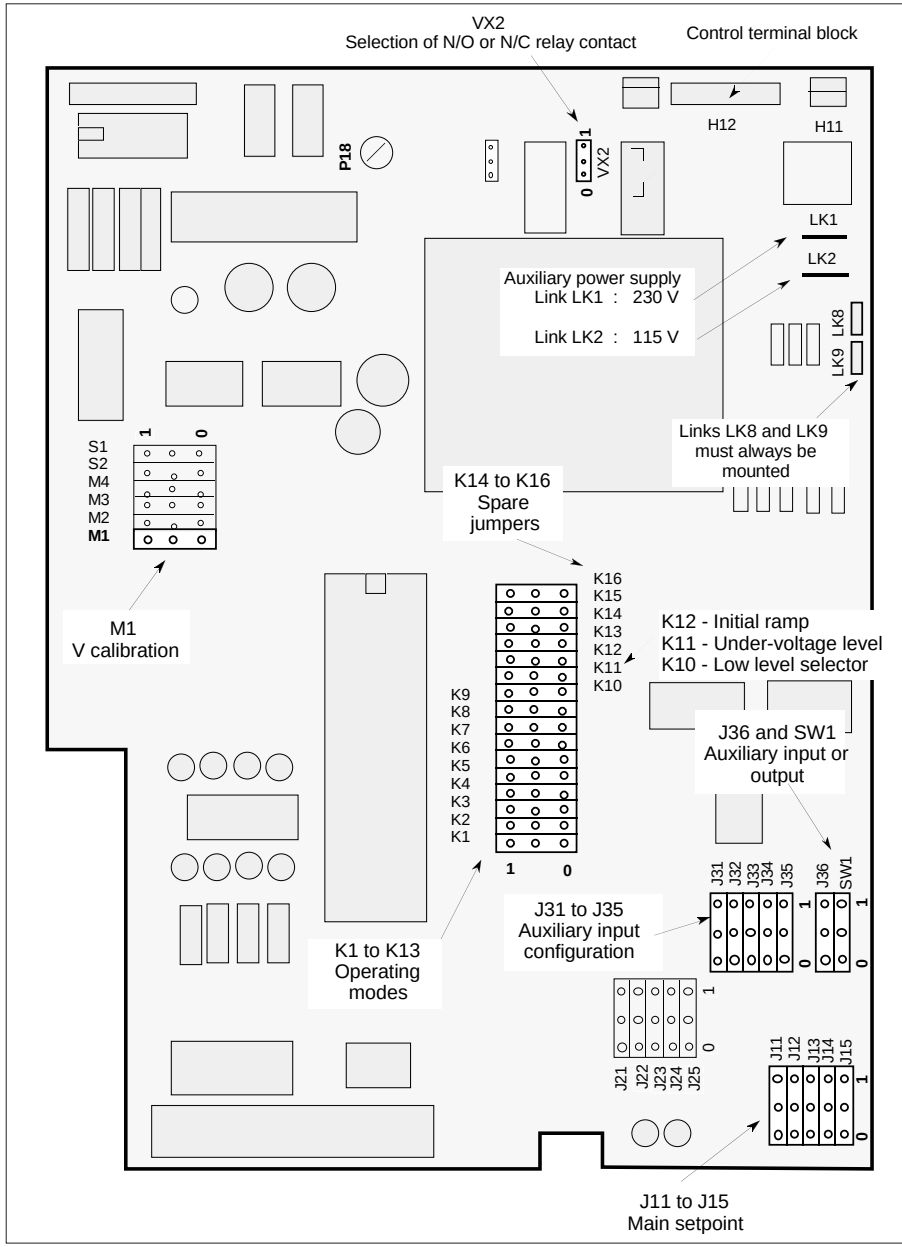

Figure 4-2 Location of configuration and calibration jumpers on the driver board

Auxiliary power supply

Two soldered links **LK1** and **LK2** on the driver board are used to configure the auxiliary voltage (the electronic and fan power supply) as **100 V to 120 V** or as **200 V to 240 V**.

Note:

The power board also contains jumpers which are labelled **LK.**

Auxiliary voltage	**Link soldered on the driver board in the factory**
100/110/115/120 V	LK2
200/220/230/240 V	LK1

Table 4-4 Auxiliary power supply configuration

Caution !

The fans for fan-cooled units are **single-voltage.**

They cannot be powered with a voltage other than that indicated on the fan.

Consequently, the auxiliary power supply voltage **configuration** must **correspond** to the nominal voltage of the fan.

Main setpoint configuration

The five jumpers **J11** to **J15** are used to configure the analogue control main setpoint signal type (voltage or current) and the signal scale from the six available scales.

Main setpoint signal type and scale		Position of jumpers				
		J11	**J12**	**J13**	**J14**	**J15**
Voltage	0 - 5 V	1	1	0	0	0
	1 - 5 V	0	1	0	0	0
	0 - 10 V	1	0	1	0	0
	2 - 10 V	0	0	1	0	0
Current	0 - 20 mA	1	0	0	1	1
	4 - 20 mA	0	0	0	1	1

Table 4-5 Main setpoint signal configuration

Process value configuration

The **process value** (squared load voltage, external feedback or operation in Open loop) is selected using the position of jumpers **K8** and **K9.**

Process value	Position of jumpers	
	K8	**K9**
Squared load voltage (V^2)	1	0
External measurement *)	0	0
Open loop	1	1

Table 4-6 Process value configuration

*) When the control is performed on the external measurement, the position of jumpers **K10**, **J36** and **SW1** is **0**.

Auxiliary input/output configuration

The position of jumpers **J36** and **SW1** defines the destination of the auxiliary input/output (terminal **12** on the control terminal block):

- **the input** (used for the second setpoint and for the external measurement signal)
- **or the output** (used for the retransmission of the controlled parameter).

The scale of the retransmission output is: **0 - 10 V**.

The position of the jumper **K10** determines the active state of the second setpoint (**low-win** selector control activated).

Auxiliary input/output type	Position of jumpers		
	K10	J36	SW1
Second setpoint	1	0	0
Process value retransmission	0	1	1
External measurement *)	0	0	0

Table 4-7 Auxiliary input / output type configuration
*) See process value configuration, table 4-6

When operating with external measurement or with the second setpoint is selected, the type (voltage or current) and one of the six signal scales are configured using jumpers **J31** to **J35**.

Destination of auxiliary input/output	Signal type and scale		Position of jumpers J31	J32	J33	J34	J35
External measurement or Second setpoint	Voltage	0 - 5 V	1	1	0	0	0
		1 - 5 V	0	1	0	0	0
		0 - 10 V	1	0	1	0	0
		2 - 10 V	0	0	1	0	0
	Current	0 - 20 mA	1	0	0	1	1
		4 - 20 mA	0	0	0	1	1
Process value retransmission	Voltage	0 - 10 V	1	0	0	0	0

Table 4-8 Auxiliary input/output scale configuration

Thyristor firing mode configuration

The thyristor **firing** mode and the presence of the setpoint change ramp or soft start/end are determined by the position of jumpers **K1** to **K4**.

Thyristor firing mode	**Position of jumpers**	
	K1	**K2**
Logic (ON/OFF)	0	0
Thyristor firing angle variation (Phase angle)	0	1
Burst firing	1	0

Table 4-9 Thyristor firing mode configuration

Soft start/end ramp	**Position of jumpers**	
	K3	**K4**
Without ramp and without soft start/end	0	0
Positive ramp in Phase angle or Soft start in Burst firing and in ON/OFF	1	0
Positive and negative ramps in Phase angle or Soft start/end in Burst firing and in ON/OFF	1	0

Table 4-10 Presence of the ramp in soft start/end

The **number of burst times** of the Burst firing cycle, the duration of the ramp on the setpoint changes or the soft start/end **time** can be adjusted using the potentiometers on the front panel (see 'Operation' chapter).

Configuration type and load type

The three-phase load configuration is determined by the position of the jumpers **K5** and **K6** on the driver board and **LK7**, **LK8** and **LK9** on the power board.

Caution !

It is necessary to check that the position of the jumpers **LK7** to **LK9** (table 4-2) corresponds to the position of the jumpers **K5** and **K6** (table 4-11).

Three-phase load configuration type or load type	Position of jumpers		
	K5	K6	K7
Star without neutral (3 wires)	0	0	
Star with neutral (4 wires)	1	0	
Closed delta (3 wires)	0	1	
Open delta (6 wires)	1	1	
Resistive load			0
(Inductive load or transformer)			1

Table 4-11 Load connection type and load type configuration

Alarm relay contact type

The **general** alarm relay is **deactivated** at the time of the alarm or when the auxiliary power supply is switched off.
The jumper **VX2** is used to select the type of N/O and N/C contact available on the user terminal block below the thyristor unit (see figure 3-1).

Important !

The relay contact is protected by RC snubbers against interference.

Relay contact type	Position of jumper VX2
Normally open (N/O)	1
Normally closed (N/C)	0

Table 4-12 General alarm relay contact type configuration

Under-voltage alarm level

If the supply voltage **drops** below the **selected value** (**50 % or 70 %**) with reference to the operating voltage, the under-voltage alarm **inhibits** the thyristor unit operation and produces an indication using a relay and the front panel display.

The alarm threshold can be configured using the jumper **K11**.

Voltage threshold	**Position of jumper K11**
Voltage less than 50 % $\mathbf{V_N}$	1
Voltage less than 70 % $\mathbf{V_N}$	0

Table 4-13 Under-voltage alarm level configuration

In the above table, $\mathbf{V_N}$ indicates the **operating voltage** of the thyristor unit or **recalibrated** operating voltage if unit has been recalibrated.

Initial ramp

The **TC3000** thyristor unit can be configured (jumper **K12)** with a thyristor firing angle variation ramp during each power-up or after a power cut for more than 20 ms.

The power-up ramp (**initial ramp**) is applied during the **first** burst or in Logic mode. For 32 supply cycles, the thyristor firing angle in each channel gradually changes from the thyristor OFF state to full firing.
The initial ramp ensures easy power-up. The subsequent bursts start at zero voltage for purely resistive loads.

Initial ramp	**Position of jumper K12**
No initial ramp	0
Initial ramp activated	1

Table 4-14 Initial ramp configuration

Calibration / Operation

The jumper **M1** is used to configure the thyristor unit either in the **voltage calibration position**, or in the normal **operation position**, excluding the calibration procedure.

The thyristor unit can be calibrated easily using the potentiometer **P6** on the potentiometer board (see 'Commissioning' chapter).

The analogue calibration signals (or RMS current and load voltage images) can be read using the **EUROTHERM** type **260** diagnostic unit (see page 6-6).
A diagnostic socket is provided for this purpose on the front panel of the thyristor unit.

Warning !

For safety reasons, the reconfiguration of the thyristor unit using jumpers must be performed by a qualified person.

Calibrated parameter or image of an operating parameter		**Corresponding jumper**	**Position of jumpers**	
			Thyristor unit calibration	**Thyristor unit operation**
Squared load voltage	V^2	M1	0	1

Table 4-14 Thyristor unit operating mode configuration (calibration or normal operation)

After recalibration the jumper **M1** must be set back to **1** position.

Chapter 5

OPERATION

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Chapter 5 OPERATION

BLOCK DIAGRAM

The interaction between the main parts of the thyristor unit is shown in figure 5-1.

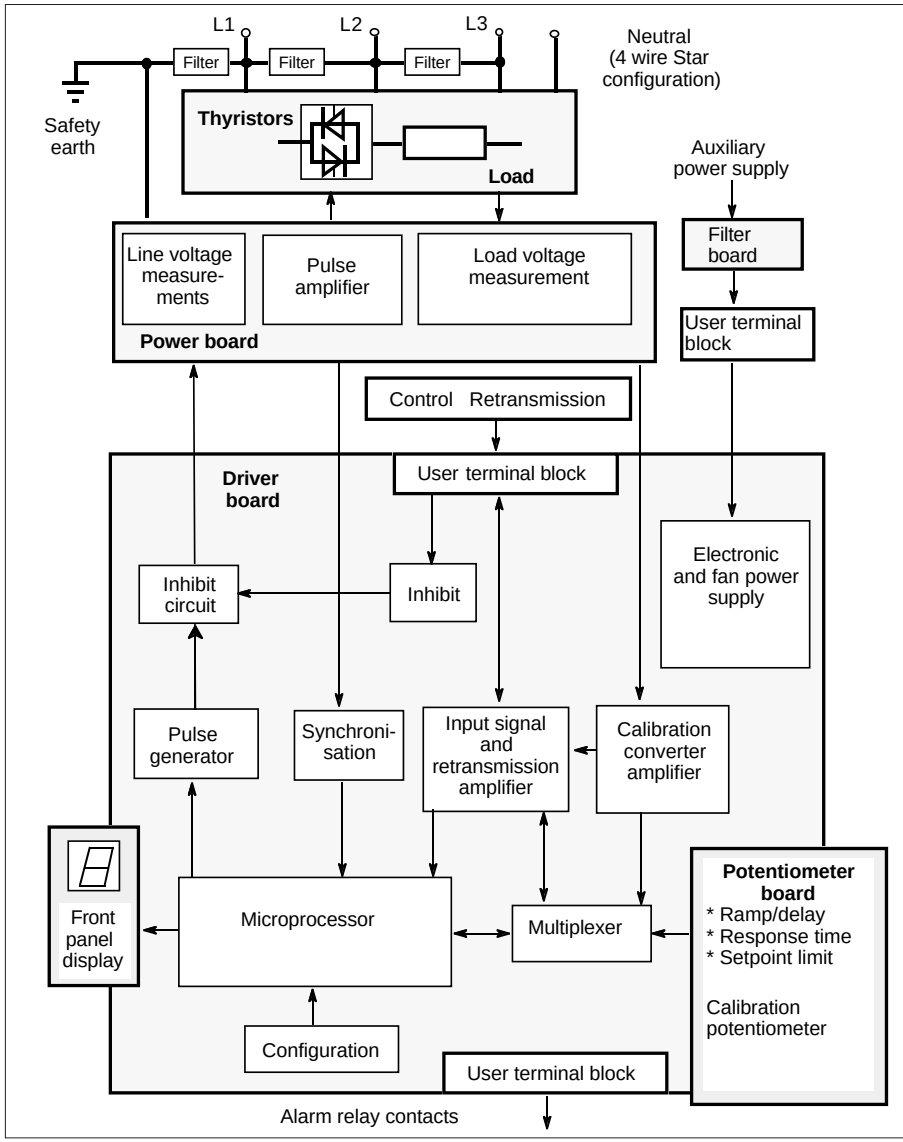

Figure 5-1 TC3000 thyristor unit block diagram

Thyristors

The 3 pairs of thyristors modulate the power supply voltage which is applied to the three-phase load.

Warning !

Thyristors up to **250 A** nominal current are mounted in a module **isolated** from the heatsink. The **300 A** to **500 A** unit heatsinks are **not isolated** from the thyristors.

Power board

The thyristor firing pulses, generated by the driver board, are amplified and transmitted to the thyristors via pulse **transformers** which provide isolation.

A voltage transformer is used to **measure the load voltage**.

Three voltage transformers are used for **synchronisation** on the power supply voltage.

Potentiometer board

Three operation potentiometers located on the **potentiometer board** (which is mounted perpendicular to the driver board) can be accessed on the front panel. They are used to adjust the main thyristor unit operating parameters without having to open the front door.
One calibration potentiometer can be accessed when the front door is open.

The functions of the operation potentiometers are indicated on the front panel of the thyristor unit and are explained in the relevant paragraph (page 5-13).

If the thyristor unit is replaced, the potentiometer board can be transferred to the new thyristor unit and thus retain all the settings specific to the application concerned.

Display

The **7** segment display is used for steady and flashing messages indicating the current operating mode of the thyristor unit, the alarm state and the error or failure type.

Diagnostic socket

The values from the control and the operation of the thyristor unit are available on the diagnostic socket located on the front panel. It is used to measure the voltages of 20 points on the electronic circuit with a EUROTHERM type 260 diagnostic unit.

Driver board

The analogue control signals and parameter retransmission are applied to the driver board **user terminal blocks**.

The **pulse generator** emits the firing pulses for the thyristor gates at the request of the microprocessor.

An inhibit line stops the oscillations if the thyristor unit is disabled (by disconnecting the 'Enable' input from the '+10V' terminal on the user terminal block or via the external input).

The **synchronisation** circuit supplies the microprocessor with three signals corresponding to the sign of the line voltages measured and a signal corresponding to the zero voltage crossing.

A squaring circuit supplies one signal corresponding to the square of the measurement load voltage: $\mathbf{V^2}$.

The **multiplexer** selects the signal applied to the analogue/digital converter inside the microprocessor from the measurements, front panel potentiometer voltages and the control signals, according to the program procedure.

The driver board **microprocessor** controls the entire operation of the thyristor unit and the message display.

The amplification of the input signals converts the low level signals and amplifies the retransmission.

A **relay** is used for the external detection of the active alarm state.

Important !

Each external link, each control or retransmission signal and the auxiliary power supply are protected against interference by an internal filter.

A **diagnostic socket** located on the front panel of the thyristor unit is used, with the **EUROTHERM type 260** diagnostic unit, to control or measure the main thyristor unit operating parameters.

The **watchdog** monitors the correct functioning of the software; in the event of a fault, it sends a '**Reset**' signal to the microprocessor.

THYRISTOR FIRING MODES

'Phase angle' mode

In '**Phase angle**' mode, the power transmitted to the load is controlled by firing the thyristors on a part of the supply voltage half-cycle.

For the three-phase load configuration in star **with neutral**, the load voltage is composed of portions of supply '**phase-neutral**' half-cycles.

For the three-phase load configuration in **open** delta, the load voltage is composed of portions of **line-to-line** voltage half-cycles.

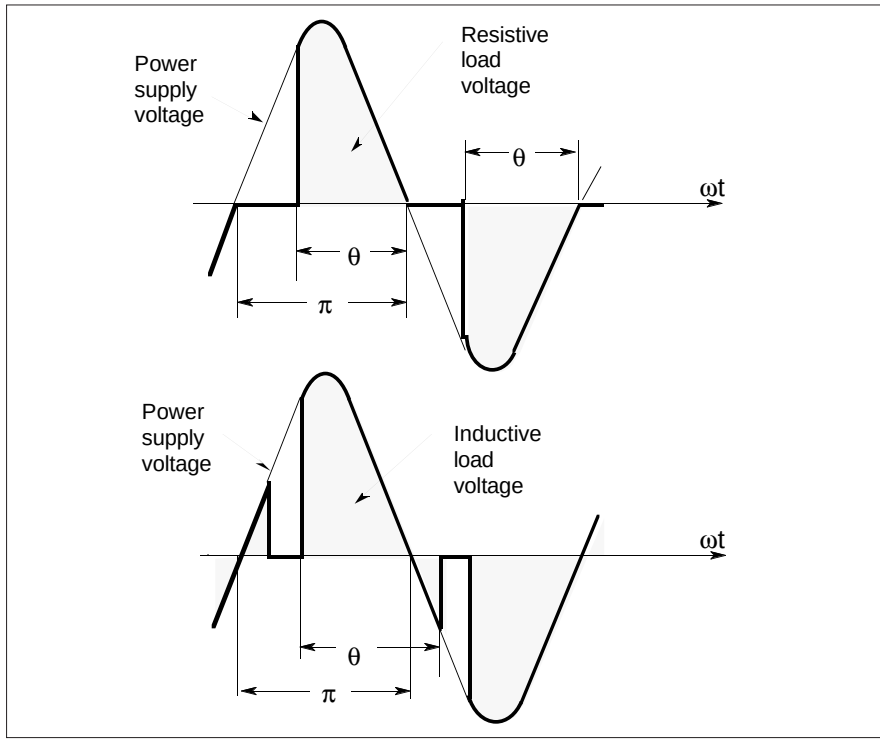

Figure 5-2 Load voltage in 'Phase angle' (star with neutral or open delta)

The firing angle (θ) varies in the same way as the control system signal.

The output power is not a linear function of the firing angle,
but is a **linear** fonction of the **input signal**.

The three-phase load voltage, configured in star **without neutral** or in **closed** delta (3 wire configuration), is composed of portions of **two**- or **three-phase** waves according to the thyristor firing angle value.

In **two-phase** operation, the thyristor output voltage (between 'LOAD' terminals) is the voltage between two **firing** phases.
In the star without neutral configuration, this voltage is applied to the 2 arms of the load in series. In the closed delta configuration, this voltage is applied to one load arm, connected between 2 firing phases and on the other 2 load arms in series.

In **three-phase** operation, the voltage of each load arm is the **phase** voltage for the star without neutral configuration or the **line-to-line** voltage for the closed delta configuration.

The figure below shows two examples of **three-phase resistive** voltages configured in star without neutral.

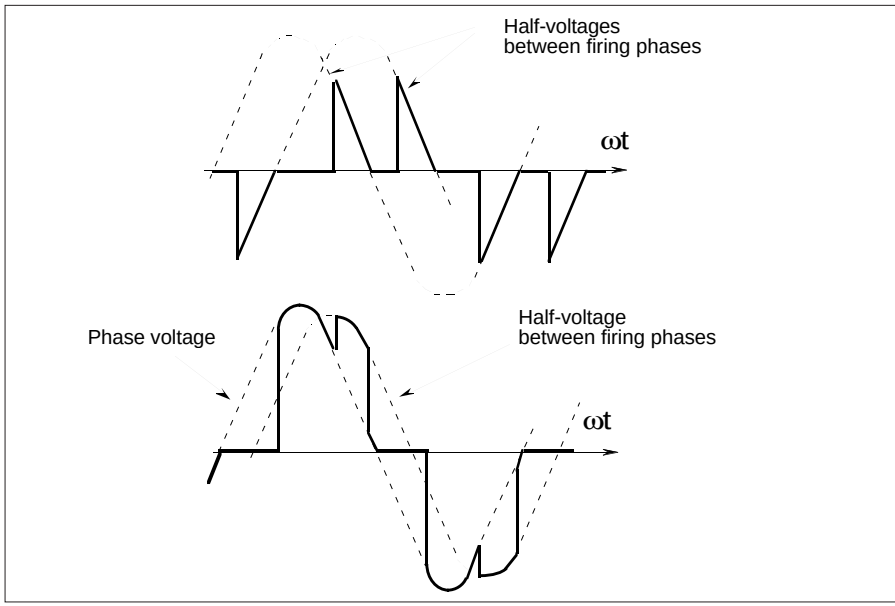

Figure 5-3 Resistive load voltage (star without neutral) in 'Phase angle'

For a small firing angle ($\theta<30°$), the load voltage is composed of portions of half-voltages between phases (figure 5-3,a).

For a large firing angle ($\theta>30°$), the load voltage is composed of portions of voltage of one phase and portions of half-voltages between phases (figure 5-3,b).

The **Phase angle** mode is used to start with small thyristor firing angles (to prevent over-currents when switching on cold low resistance loads or transformer primary coils).

The gradual increase in the firing angle depends on the operation selected by the user (**ramp** on the setpoint change) or is under the control of the **initial** safety ramp (32 supply cycles).

The ramp on the setpoint change can be **positive** (gradual increase in the firing angle during the power increase request) or **positive and negative** (gradual increase and decrease in the thyristor firing angle).

The table below gives the possible types of operation in '**Phase angle**' firing mode (code **PA**).

Mode	**Code**	**Corresponding operation**
Standard	NRP	Thyristor firing angle dependent on the control signal
Ramp	URP	Positive ramp with adjustable slope on the setpoint change.
	UDR	Positive and negative ramps with adjustable slopes on the setpoint change.

Table 5-1 Possible types of operation in 'Phase angle' mode

'Logic' mode

The '**Logic**' thyristor firing mode ('**ON/OFF**') controls a power in the load proportionally to the firing time set by the **logic** control signal.
This firing mode is activated from an input signal greater than **50%** of the full scale and as long as the input signal is not less than **25%** of the full scale.

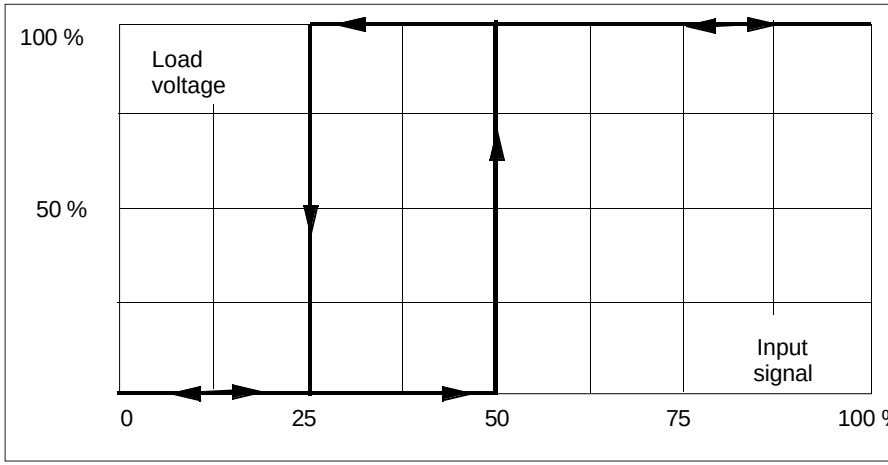

Figure 5-4 'Voltage - Logic signal' diagram

Important !
To reduce an emission of electrical interference and electromagnetic radiation, the thyristors are switched at zero voltage for resistive loads.

This produces a slight **unbalance** of the power in the three arms of the load. In order to eliminate the DC component generated on each phase, **firing rotation** is performed (patented by Eurotherm Automation). This can only be used with resistive loads not with inductive loads.

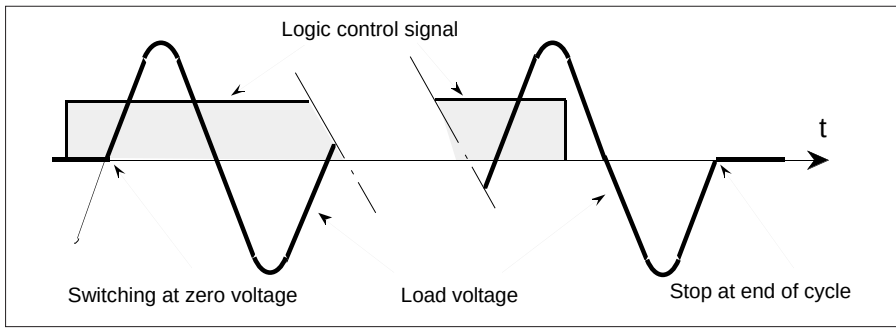

Figure 5-5 'Logic' firing mode

The **Logic** can also be configured with a **soft** start (or start and end) in thyristor firing angle variation. There are two possibilities:

- **start** in **Phase angle** with the firing angle increased gradually and **immediate stop** at the end of the voltage supply cycle (as soon as the control signal is less than **25%**)
- **soft** start **and** non-firing in **Phase angle**.

For inductive loads, zero voltage crossing generates transient operation which may, in certain cases, induce a saturation of the magnetic circuit (see fig.5-6,a) and a high speed fuse blow-out (thyristor protection).

To prevent this saturation, the firing on each phase can be **delayed** with reference to the corresponding zero voltage (see figure 5-6,b).

The optimum **delay angle (**ϕ) must be set with the front panel potentiometer '**PA Ramp/CY Delay**', as a function of the load (max. delay 90°).

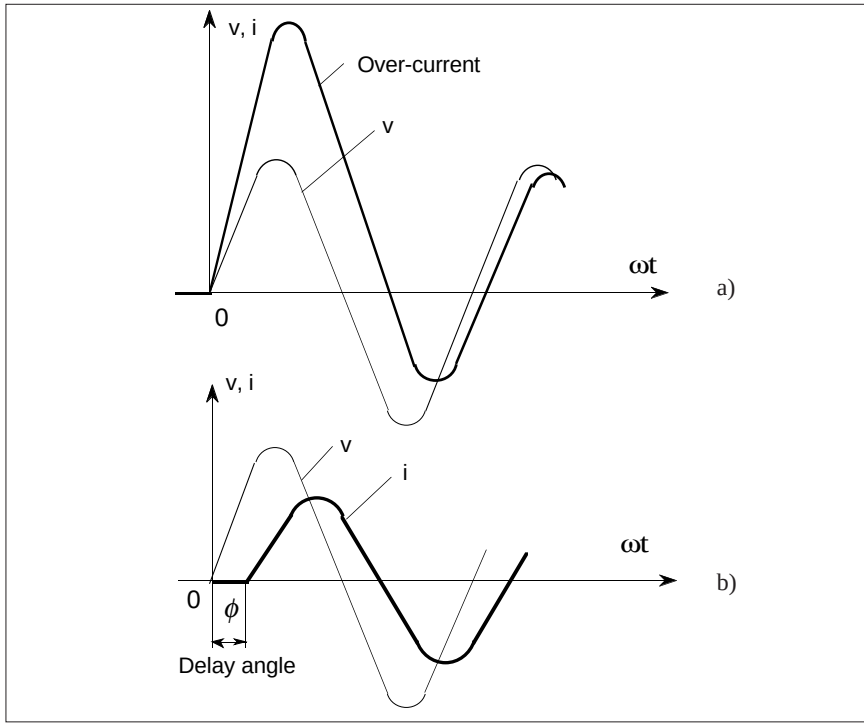

Figure 5-6 Inductive load switching at zero voltage (a) and with a delay angle (b)

The table below gives the possible types of operation in '**Logic**' mode (code **LGC**).

Mode	**Code**	**Corresponding operation**
Standard	NRP	ON time corresponds to the time that the control signal is present. Code **RES**: Thyristor zero voltage switching on each phase (each new firing starts at the different zero voltage). Code **IND**: On each phase, the first firing is delayed by an adjustable angle.
Soft Adjustable time.	URP	Soft start with thyristor firing angle variation from zero to full firing. Immediate stop at end of cycle. (Default code **RES**)
	UDR	Soft start and end with thyristor firing angle variation from zero to full firing and from full firing to zero. (Default code **RES**)

Table 5-2 Possible types of operation in 'Logic' (ON/OFF) mode

'Burst firing' mode

The '**Burst firing**' mode is a **proportional cycle** which consists of supplying a series of **complete** power supply voltage **cycles** to the load.

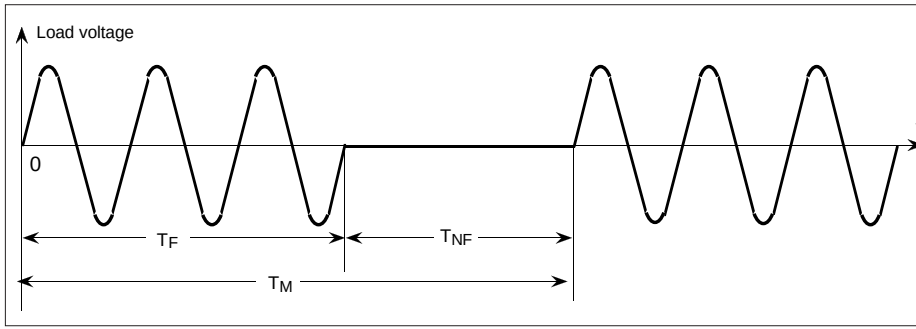

Figure 5-7 'Burst firing' mode (T_F - firing time; T_M - modulation time)

The 'Burst firing' mode with **a single** firing mains cycle (or a single non-firing mains cycle) is called the "**Single cycle**" firing mode.

Thyristor firing and non-firing are synchronised with the power supply and are performed **at zero voltage** for a resistive load. Each new firing starts at the zero voltage of a different phase in order to rebalance the power consumption of the 3 phases and to eliminate the DC component (firing **signal rotation** is covered by a Eurotherm patent).

In Burst firing mode, control is performed with a constant firing time $\mathbf{T_F}$ (or non-firing time $\mathbf{T_{NF}}$) and a **variable modulation time $\mathbf{T_M}$**.
The firing time $\mathbf{T_F}$ is selected by the user.

Important !

For **less than 50%** power, the **firing** time is **constant.**
For **more than 50%** power, the **non-firing** time is **constant.**
For 50% power, the firing time is **equal** to the non-firing time.

The Burst firing modulation period time ($\mathbf{T_M}$) is determined by the control as a function of the set firing (or non-firing) time, the setpoint, the feedback and the process algorithm.

The control system **adjusts** the basic burst firing modulation times ($\mathbf{T_M}$) in order to retain optimum accuracy irrespective of the output power.

The **'Burst firing'** mode (codes **FC1 to 255**) can be configured **with:**

- soft start (or start and end) in thyristor firing angle **variation** during the required time (limited by the firing time)
- the firing **delay** of the first firing thyristor, at each cycle

The table below indicates possible operation in Burst firing mode.

Mode	Code	Corresponding operation
Standard Number of firing (or non-firing) cycles selected by the user.	NRP	Proportional cycle with a modulation time determined by the control system. Code **RES**: Thyristor zero voltage switching on each phase (without DC component). Code **IND** : On each phase, the first firing is delayed by an adjustable angle
Soft Adjustable ramp time. Limited by the basic cycle time (firing time).	URP	Soft start with thyristor firing angle variation from zero to full firing. Stop at end of supply cycle. (Default code **RES**)
	UDR	Soft start and end with thyristor firing angle variation from zero to full firing and from full firing to zero. (Default code **RES**).

Table 5-3 Possible types of operation in 'Burst firing' mode

SETTING POTENTIOMETER FUNCTIONS

Three potentiometers are provided to enable the user to set the operation of the **TC3000** thyristor unit without opening the front door.

They are available on the top left section of the thyristor unit front panel.

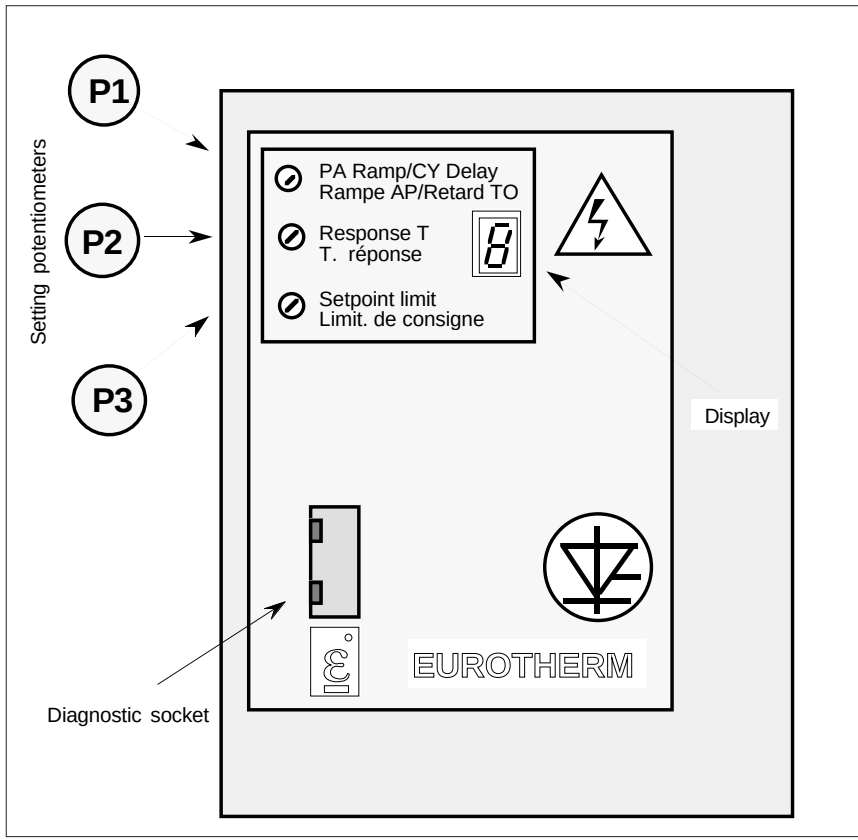

Figure 5-8 Front panel potentiometers

The setting potentiometers are **10** turns.

The functions of the potentiometers **P1**, **P2** and **P3** depend on the selected firing mode and the thyristor unit configuration (load type, selected ramp, soft start or start and end).

The potentiometer functions are summarised in the table below.

Potentio-meter	**Designation on front panel**	**Firing modes**	**Function**
P1	PA Ramp/ CY Delay	Phase angle	Ramp setpoint setting
		Logic Burst firing	First half-cycle delay angle setting (for inductive loads only).
P2	Response T.	Phase angle	Control loop response time setting.
		Burst firing	Basic burst firing time setting.
P3	Setpoint limit	All excepted Logic mode	Setpoint limit setting.

Table 5-4 Summary of the front panel potentiometer functions

'PA Ramp / CY Delay' potentiometer

The potentiometer **P1** labelled '**PA Ramp / CY Delay**' on the front panel is used to set the following:

- **the ramp on the setpoint changes** (Phase angle firing mode);
- **the soft start/end** (Burst firing and Logic firing modes);
- **the delay angle** (Burst firing and Logic firing modes).

Conditions and positions of jumpers			**Functions of potentiometer P1 'PA Ramp / CY Delay'**
Firing mode	**Operation**		
Phase angle K1 = 0 K2 = 1	No ramp	K3 = 0	**No** action
	Positive ramp	K3 = 1 K4 = 0	Ramp **duration** setting (number of supply cycles) for setpoint **changes**. The ramp is enabled for power **increase** requests
	Positive and negative ramp	K3 = 1 K4 = 1	Ramp **duration** setting (number of supply cycles) for **both** power **increase** and **decrease** requests
Logic K1 = 0 K2 = 0	Resistive load. No soft start	K7 = 0 K3 = 0 K4 = 0	**No** action
Burst firing K1 = 1 K2 = 0	Inductive load. No soft start	K7 = 1 K3 = 0	Setting of **first** alternation firing **delay** from **0°** to **90°**
	All loads Soft start	K3 = 1 K4 = 0	**Start duration** setting (number of supply cycles) in thyristor firing angle variation. **Immediate stop** after first 0 crossing.
	All loads Soft start and end	K3 = 1 K4 = 1	Setting of **both start** and **end** duration in thyristor firing angle variation

Table 5-5 Functions of the potentiometer P1 for the various firing modes

Note: For the Burst firing and Phase angle burst modes, the soft operation time is limited by the basic cycle.

Setpoint change ramp

The ramp duration ($\mathbf{T_r}$) is the number of supply cycles (therefore, the time taken) for the thyristor unit firing to **change** from **0%** to **100%** (**positive** ramp) or from **100%** to **0%** (**negative** ramp).

The **Setpoint change ramp** function is only available in the 'Phase angle' firing mode.

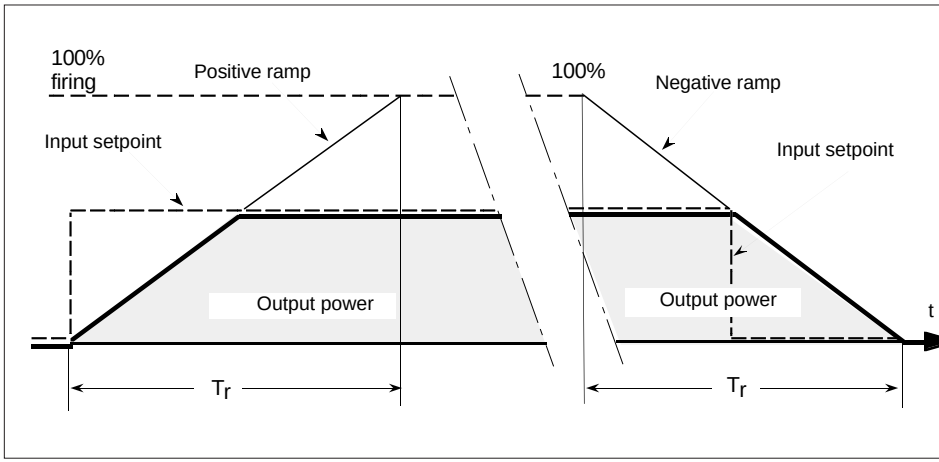

Figure 5-9 Positive and negative ramps during setpoint change in Phase angle mode

After the electronics power-up, the setpoint ramp is reset to zero.
If the setpoint has not changed, the setpoint ramp is not enabled when the thyristor unit is re-enabled after an inhibit.

Important !

The ramp duration is set for **both** the positive and negative ramps.

For the same $\mathbf{T_r}$ setting, the **slope** of the ramp is **constant** irrespective of the setpoint change amplitude.

The setting made using the potentiometer **P1** can be read using the Eurotherm type 260 diagnostic unit (in the form of a setting voltage in position **11**).

The $\mathbf{T_r}$ values (in number of supply cycles elapsed in ramp and in time) and the corresponding setting voltages are given in the table below.

P1 Setting voltage (read in position 11 of the diagnostic unit)	Ramp duration (Tr)		
	Number of cycles	50 Hz power supply	60 Hz power supply
0.10 V	4	0.08 s	0.066 s
0.25 V	8	0.16 s	0.133 s
0.40 V	16	0.32 s	0.266 s
0.55 V	32	0.64 s	0.53 s
0.72 V	64	1.28 s	1.06 s
0.85 V	128	2.56 s	2.12 s
1.00 V	256	5.12 s	4.24 s
1.20 V	512	10 s	8.5 s
1.30 V	1,024	20 s	17 s
1.50 V	2,048	41 s	34 s
1.65 V	4,096	1 min 22 s	1 min 8 s
1.80 V	8,192	2 min 44 s	2 min 16 s
1.95 V	16,384	5 min 28 s	4 min 32 s
2.10 V	32,764	11 min	9 min
2.30 V	65,528	22 min	18 min
2.40 V	131,000	44 min	36 min
2.60 V	262,000	1 hour 27 min	1 hour 12 min
2.75 V	534,000	3 hours	2 hours 30 min
2.90 V	1,050,000	6 hours	5 hours
3.10 V	2,100,000	12 hours	10 hours
3.25 V	4,190,000	24 hours	20 hours
4.00 V	8,390,000	48 hours	40 hours

Table 5-6 Ramp setting during setpoint change in 'Phase angle'

The duration $\mathbf{T_r}$, set by the user, is given in table 5-6 for a change of the input signal from **0** to **100%**.

Important !

The positive ramp is completed as soon as the firing angle corresponding to the current setpoint has been reached (see figure 5-9).

After inhibition (setpoint not changed) electronics supply not switched off, this ramp will not be active

Soft start / end

Soft operation (start or start and end) can be configured in the following firing modes:

- Logic and Burst firing.

The soft start duration ($\mathbf{T_{ss}}$) is the time taken for the thyristor unit output power to **change** from **0%** to **100%** with thyristor firing angle variation from **0** to **full firing**.

The soft end duration ($\mathbf{T_{se}}$) is the time taken for the thyristor unit output power to **change** from **100%** to **0%** with thyristor firing angle variation from **full firing** to **0**.

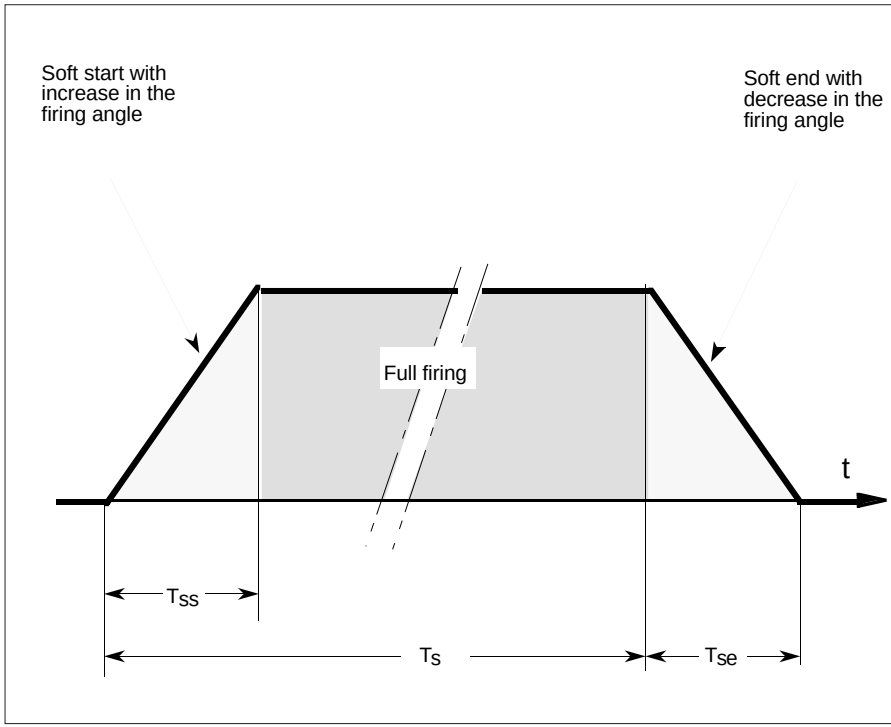

Figure 5-10 Soft start and end in Logic mode

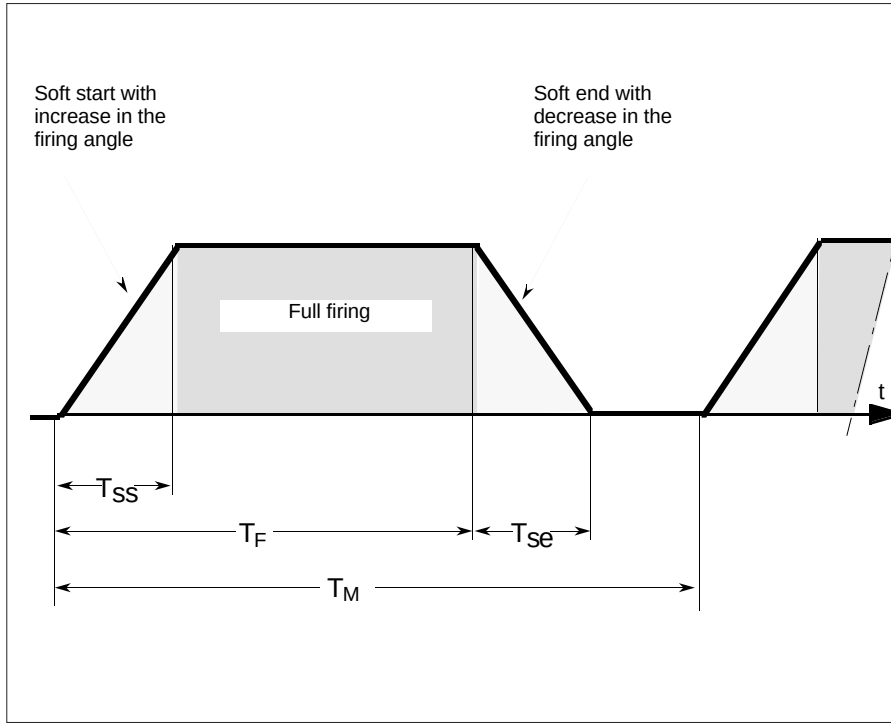

Figure 5-11 Soft start and end in Burst firing mode

In the Burst firing mode, the number of soft start cycles or soft end cycles is limited to the number of supply cycles in the selected firing time.

The soft start time ($\mathbf{T_{SS}}$) is not included in the firing time ($\mathbf{T_F}$), but all the power sent in the load is taken into account in the control.

After the soft start with thyristor firing angle variation, the thyristor unit remains in **full firing**:

- during the time the input signal is present $\mathbf{T_S}$ (in Logic mode)
- during the firing time of one modulation time $\mathbf{T_M}$ (in Burst firing mode).

The duration of the thyristor firing angle change is set using the potentiometer P1 for **both** the start and the end ($\mathbf{T_{SS}}$ always **equal** to $\mathbf{T_{se}}$).

The soft start and end duration can be set using the potentiometer **P1** from **0** to the number of modulation times.

The maximum soft start/end duration corresponds to the number of burst times in the basic cycle (selected modulation time).

The setting position of the potentiometer **P1** can be read using a EUROTHERM type 260 diagnostic unit in the form of a setting voltage in position **11**.

P1 **Setting voltage (read in position 11 of the diagnostic unit)**	**Soft start/end duration (T_{SS} = T_{se})**		
	Number of cycles	**50 Hz power supply**	**60 Hz power supply**
0.05 V	0	0	0
0.10 V	1	20 ms	16.6 ms
0.15 V	2	40 ms	33.3 ms
0.25 V	3	60 ms	50.0 ms
0.35 V	5	100 ms	83.3 ms
0.40 V	8	160 ms	133 ms
0.50 V	16	320 ms	266 ms
0.55 V	32	640 ms	533 ms
0.70 V	37	740 ms	616 ms
1.30 V	43	860 ms	716 ms
2.00 V	51	1.02 s	0.85 s
2.50 V	64	1.28 s	1.07 s
3.50 V	85	1.70 s	1.42 s
4.00 V	128	2.56 s	2.13 s
5.00 V	255	5.10 s	4.25 s

Table 5-7 Soft start/end duration

Delay angle

The potentiometer **P1** adjusts the delayed firing angle of the first half-cycle for the control of **inductive** loads in the following firing modes:

- Logic and Burst firing.

A **90**° delay angle is obtained with **P1** turned completely **clockwise**.
A **0**° delay angle is obtained with **P1** turned completely **anti-clockwise**.

The scale in figure 5-12 gives the equivalence between the setting voltage $\mathbf{V_{11}}$ (read in position **11** of the diagnostic unit) and the delay angle.

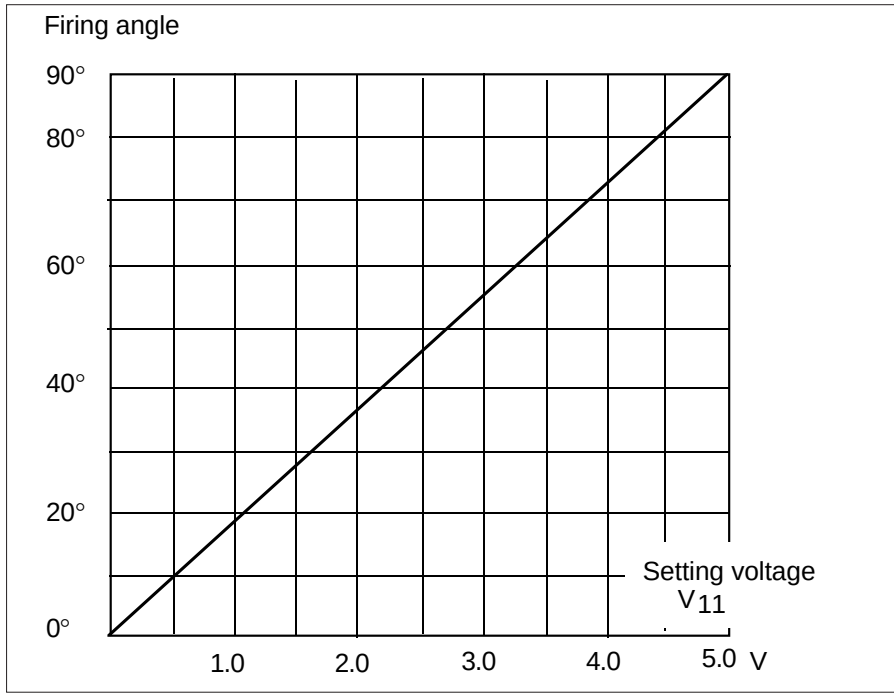

Figure 5-12 Delay angle setting scale

IIn the factory, the potentiometer **P1** is preset to **5 V** (**90**° delay angle) if the coding indicates inductive load configuration.

'Response T' potentiometer

The potentiometer **P2** labelled '**Response T**' on the front panel is used to adjust the **control loop response time** (in 'Phase angle' firing mode) or the **number of firing cycle** (in 'Burst' firing mode).

Firing mode	**Positions of jumpers**	**'Response T' potentiometer functions**
Phase angle	K1 = 0; K2 = 1	Control loop **reponse time** setting. The response time depends on the control loop gain
Logic	K1 = 0; K2 = 0	**No** action
Burst	K1 = 1; K2 = 0	Setting of the **number of** firing (or non-firing) cycles in the modulation times.

Table 5-8 Functions of the potentiometer P2

Standard response time in 'Phase angle'

The control loop response time can be adjusted from **13** to **52** supply cycles using the potentiometer **P2**. When **P2** is turned **clockwise**, the response time **is increased** (since the gain is decreased).

An increase in the gain can cause the setpoint to be exceeded transiently.
Stability can be increased, but by decreasing the control loop gain.

A satisfactory **'stability / gain'** compromise is obtained with a response time of approx. **0.68 s.** This **standard** response time (default setting) corresponds to a setting voltage of **4.3 V** (read in position **10** of the EUROTHERM type 260 diagnostic unit).

Number of mains cycles in the Burst firing basic cycle

The firing (or non-firing) time in the 'Burst firing' mode is set using the potentiometer **P2**.

Important !

The potentiometer **P2** sets**:**
- the duration of the basic cycle **firing** time for **less than 50%** power
- the duration of the basic cycle **non-firing** time for a power **greater than or equal to 50%**

The setting varies between **a single** supply cycle ('**Single cycle**' firing mode) and **255** supply cycles.

The setting made can be **read** using the Eurotherm type 260 diagnostic unit in position **10** (in the form of a **setting voltage**).

P2 Setting voltage (read in position 10 of the diagnostic unit)	**Basic firing (or non-firing) time**		
	Number of cycles	**50 Hz power supply**	**60 Hz power supply**
0 V	1	20 ms	16.6 ms
0.5 V	2	40 ms	33.3 ms
1.0 V	4	100 ms	83.3 ms
2.0 V	8	160 ms	133.3 ms
2.5 V	16	320 ms	266.6 ms
3.0 V	32	640 ms	533.3 ms
3.5 V	64	1.28 s	1.07 s
4.5 V	128	2.56 s	2.13 s
5.0 V	255	5.10 s	4.25 s

Table 5-9 Basic cycle firing (or non-firing) time

'Setpoint limit' potentiometer

The potentiometer **P3** labelled '**Setpoint limit**' on the front panel can be used to **limit the input signal setpoint**.

The input signal limit function is **enabled** in the Phase angle and Burst firing modes, but **does not act** when the TC3000 thyristor unit is configured in **Logic** firing mode.

The setpoint limit setting made using the potentiometer **P3** can be **read** using the Eurotherm type 260 diagnostic box in position **9** (in the form of a setting voltage-$\mathbf{V_9}$).

The setting voltage value $\mathbf{V_9}$ of the limit input signal $\mathbf{E_{LIM}}$ (in **%** of the selected **scale**) can be obtained according to the equation:

$$\mathbf{V_9} = \mathbf{5\ V} \quad \mathbf{x} \quad \frac{\mathbf{E_{LIM}\ \%}}{\mathbf{100\%}}$$

where $\mathbf{E_{LIM}}$ represents the value of the limited input value.

E.g.: Required setpoint limit $\mathbf{E_{LIM} = 65\%}$

Setting voltage (read in position **9**)

$$\mathbf{V_9} = \mathbf{5\ V} \quad \mathbf{x} \quad \frac{\mathbf{65\%}}{\mathbf{100\%}} = \mathbf{3.25\ V}$$

This setting obtained means that when the input signal is **100%**, the output power reaches **65%** of its nominal value (or calibration value).

When the input signal is **20%**, the output power is only **13%** of its nominal value:

$$\frac{\mathbf{20\ \% \times 65\%}}{\mathbf{100\%}} = \mathbf{13\%}$$

CONTROL OPERATION

The internal control loop algorithm of the **TC3000** series thyristor unit takes into account the feedback value selected by the user using the configuration jumpers (see 'Configuration' chapter).

The controlled parameters are as follows:

- squared load voltage - **V^2**
- external (feedback) measurement - **External measurement**

For the control signal applied on the **analogue** input, the response curve is **linear** between **0%** and **100%** with 'dead bands' between 0 and 2% and between 98% and 100%.

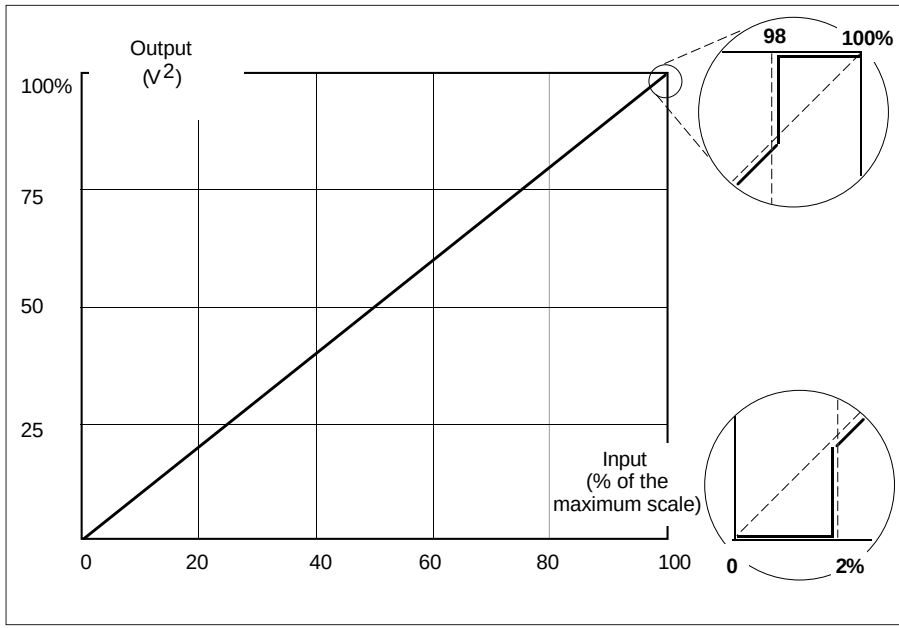

Figure 5-13 'Input/Output' response curve

The output power of the thyristor unit is calibrated according to the **selected** process **value** and the thyristor unit calibration (see 'Calibration' section, page 6-8).

Squared load voltage

The **V²** controlled parameter is the square of the **RMS load** voltage:
This voltage is taken according to the load configuration type.

- The control voltage is taken between phases **1** and **2** of the load for closed or open delta and star without neutral configurations,

- The control voltage is taken between phase **1** of the load and the **neutral** for a star with neutral configuration.

External measurement

The **external feedback** signal has four voltage scales and two current scales.

- Voltage:
  0 - 5 V ; 1 - 5 V, 0 - 10 V, 2 - 10 V.
  Input impedance ≥ 100 kΩ.

- Current:
  0 - 20 mA ; 4 - 20 mA
  Input impedance 100 Ω.

Chapter 6

COMMISSIONING PROCEDURE

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Chapter 6 COMMISSIONING PROCEDURE

Read this chapter carefully before commissioning the thyristor unit

COMMISSIONING PROCEDURE SAFETY

Important !

Eurotherm cannot be held responsible for any damage to persons or property or for any financial loss or costs resulting from the incorrect use of the product or the failure to observe the instructions contained in this manual.

It is therefore the user's responsibility to ensure that all the nominal values of the power unit are compatible with the conditions of use and installation before commissioning the unit.

Warning !

Dangerous live parts may be accessible when the front door is open.

Only personnel qualified and authorised to work in industrial low voltage electrical environments can access inside the unit.

Access to internal components of the thyristor unit is prohibited to users who are not authorised to work in industrial low voltage electrical environments.

The temperature of the heatsink may exceed 100°C.
Avoid all contact, even occasional, with the heatsink when the unit is in operation. The heatsink remains hot approximately 15 min after the unit has been switched off.

CHECKING THE CHARACTERISTICS

Caution !

Before connecting the unit to an electrical supply, make sure that the **identification code** of the thyristor unit corresponds to the coding specified in the **order** and that the characteristics of the thyristor unit are **compatible with the installation**.

Load current

The maximum load current must be less than or equal to the value of the nominal current of the thyristor unit taking the load and power supply variations into account.

If the three identical loads are configured in **closed delta**, the current of each phase of the thyristor unit is $\sqrt{3}$ times **higher than** as the current of each **arm** of the load.

For the given power (**P**) of the three-phase load and for the line voltage $\mathbf{V_L}$ (line-to-line voltage), the current to be compared with the nominal thyristor unit current is:

$$\mathbf{I} = \frac{\mathbf{P}}{\sqrt{3} \times \mathbf{V_L}}$$

For the open delta, the current to be compared with the nominal thyristor unit current is:

$$\mathbf{I} = \frac{\mathbf{P}}{3 \times \mathbf{V_L}}$$

Load configuration type

Make sure that the configuration type used is correctly configured using the jumpers

- **K5** and **K6** on the driver board (see page 4-12)
- **LK7**, **LK8** and **LK9** on the power board (see page 4-5).

Power supply voltage

The **voltage applied** to thyristors in the OFF state, **depends on the load configuration type**.

For the **star without neutral**, **closed** or **open delta** configurations, the nominal value of the thyristor unit voltage must be greater than or equal to the **line-to-line** voltage of the power supply used.

For the **star with neutral** configuration, the nominal thyristor unit voltage can be greater than or equal to the voltage between the **phase and neutral** of the power supply used.

A thyristor unit can be used on a three-phase power supply of a voltage **less** than the voltage specified for the thyristor unit, by **reconfiguring** it (see table 4-1, page 4-4).

If the power supply voltage is less than **70%** of the nominal thyristor unit voltage (or 50% depending on selected configuration), after 5 s of integration, the thyristor unit changes to inhibit (thyristor control withdrawn).
The thyristor unit is re-enabled automatically if the voltage returns to a value greater than or equal to 70 % or 50% of the nominal value of the thyristor unit.

Caution !

Given the inhibit at 70 % (or 50%) of the nominal voltage, the operating (calibration) voltage must be as close as possible to the nominal power supply voltage used.

Auxiliary power supply voltage

The auxiliary power supply voltage must correspond to the supply available.

The voltage is selected in the factory, according to the order code, using soldered links on the driver board (see page 4-7).

Input signals

The jumper configurations on the driver board must be compatible with the selected levels of the analogue signals used for:

- control (see page 4-9)
- the external measurement (see pages 4-9 and 4-10).

DIAGNOSTIC UNIT

For easier commissioning and setting operations and for the thyristor unit state diagnostics, it is advisable to use the **EUROTHERM type 260** diagnostic unit.

The diagnostic unit possesses a flat cable which is plugged into the 20-pin socket (diagnostic socket) provided on the front panel of the thyristor unit.

The **20-way switch** of the diagnostic unit is used to view the values of the thyristor unit and feedback parameters on its digital display. The unit displays two decimal places for the precise indication of the selected values.
The signals from the diagnostic socket may also be viewed using an oscilloscope.

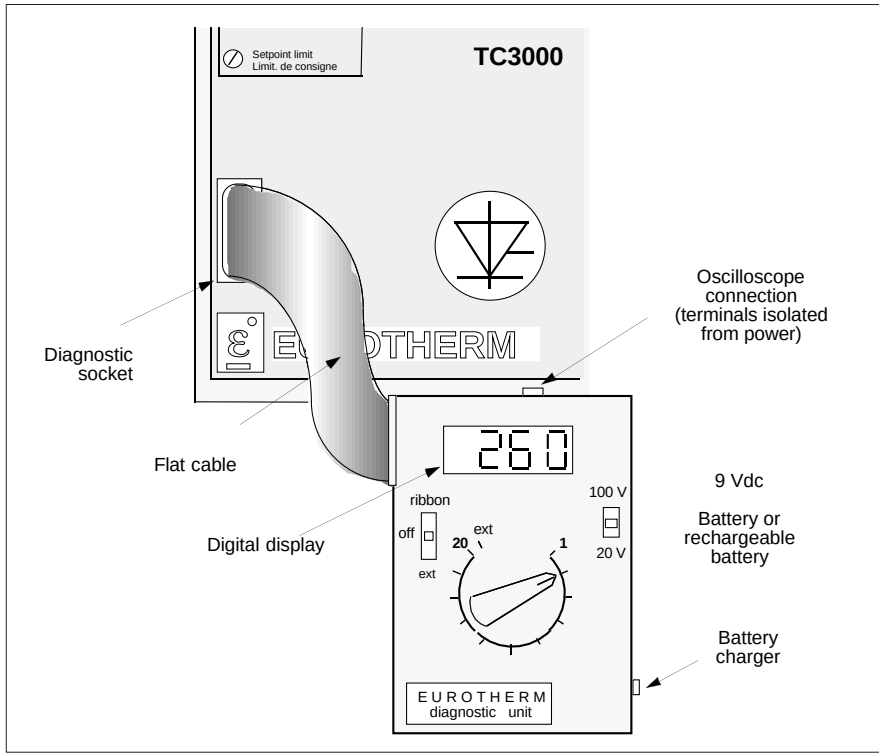

Figure 6-1 Connection of the EUROTHERM type 260 diagnostic unit and the TC3000 thyristor unit

The following table gives the description of each position of the **EUROTHERM type 260** diagnostic unit and the typical values of the signals measured.

The values measured are **DC means** values.

Position	Designation	Typical value	Remarks
1	Electronics supply	+5.6 V	
2	Reference	+5 V	
3	Electronics supply	+15 V	
4	User voltage	+10 V	Control term. block
5	Electronics supply	-15 V	-14.45 to -15.55 V
6		+21 V	Rectified, filtered
7	Input control signal (at converter output)	0 to 5 V	
9	Setpoint limit	0 to 5 V	Potentiometer **P3**
10	Burst firing cycle time	0 to 5 V	Potentiometer **P2**
11	Ramp, soft start/end or delayed firing duration	0 to 5 V	Potentiometer **P1**
15	Synchronisation	5 V pulses	Zero crossing
16	Microprocessor reset	5 V pulses	Normal operation: 0V
17	Enable	5 V logic	Inhibit: 0 V
18	Electronics supply	Common 0 V	
20	Calibration of voltage (M1=0) or Image of V in operation (M1=1)	In calibration : 0 to 10 V (set à 1.73 V for 3 phases with Neutral)	Jumper M1 = 0 Potentiometer **P6**
		In normal operation: 0 to 1.67 V	Jumper M1 = 1

Table 6-1 Destination of the positions of the EUROTHERM type 260 diagnostic unit

The positions **8**, **12** to **14** and **19** are not used in this version of the power thyristor unit.

THYRISTOR UNIT CALIBRATION

The thyristor unit is calibrated so that the **maximum value** of the selected control input signal **scale corresponds** to the **nominal values** of the **voltage** allowed by the load used.

The calibration performed also acts on the voltage retransmission signals and on the feedback signal selected for the process algorithm.

The potentiometer labelled **P6** is used to calibrate the thyristor unit voltage.
It is located on the **potentiometer board**, placed perpendicular to the driver board (see figure 1-2).
The calibration potentiometer can be accessed with the front door open.
Each potentiometer can be adjusted by **10 turns**.

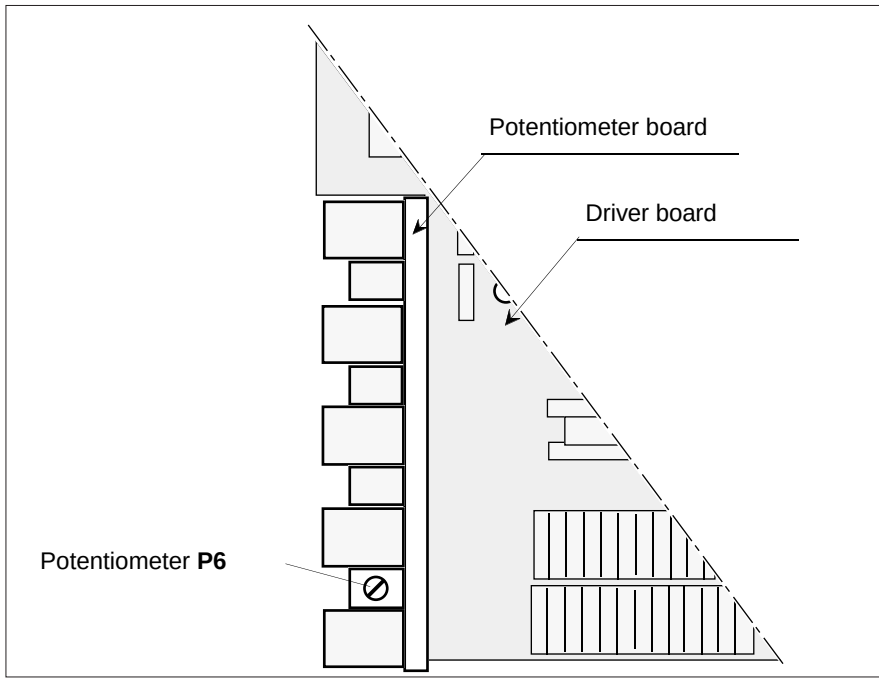

Figure 6-2 Location of calibration potentiometer

The calibration procedure must be performed using the **EUROTHERM type 260** diagnostic unit enabling accurate reading of the calibrated value.

Note: Calibration is not essential if the retransmission **is not used** or the load voltage is **close** to that of the TC3000 thyristor unit.

There are two possible types of calibration depending on the position of calibration jumper **M1:**

- **non-firing** calibration or
- **full firing** calibration.

Normally, calibration must be performed during **non-firing** (the jumper **M1** on the driver board is set to **position 0**). The calibration of the thyristor unit during non-firing does not require the operation of the installation under nominal conditions.

Once the non-firing calibrations have been **performed**, the calibration jumpers must be reset to the **operating** position (**1**).

Full firing calibration is performed if it is necessary to **fine-tune** or **readjust** the calibration **during thyristor unit operation**.
In this case, the calibration jumper must be left in the **operating position**.

In the factory, the calibration signal is adjusted for the **nominal voltage** specified in the thyristor unit order.
The following calibration procedure is optional and is only to be performed for conditions when the nominal load voltage can be changed.

Important !

If the value is calibrated at its **nominal** value, the corresponding reading on the diagnostic unit in position **20** is **1 V**
(jumper M1 in **calibration** position).

For the firing calibration, it should be taken into account that in **full firing** (sinusoidal current operation), the DC values (rectified sinusoidal signals, double alternations) read in positions **20** of the EUROTHERM type 260 diagnostic unit are **1.67 V** (**1.885 V** RMS or **2.61 V** peak to peak on the oscilloscope).

Load voltage calibration

To calibrate the voltage of the **TC3000** thyristor unit, calculate the calibration voltage ($\mathbf{V_{CA}}$) according to the following ratio:

$$\mathbf{V_{CA}(V) = 1\ V\ x\ \frac{V_{UN}}{V_{LN}}}$$

where $\mathbf{V_{UN}}$ - nominal thyristor unit voltage (see identification label)
$\mathbf{V_{LN}}$ - nominal load voltage (line-to-line voltage of the power supply used).

Important !

For a **star with neutral** configuration**,** $\mathbf{V_{CA}}$ must be multiplied by $\sqrt{3}$**.**

Calibration in calibration mode position (M1 = 0) . TC3000 cannot conduct

- By turning the potentiometer **P6**, display the value $\mathbf{V_{CA}}$ calculated on the diagnostic unit display in position **20**,
- Reset the jumper **M1** in the operating position (**1**).

Example 1: Nominal **TC3000** thyristor unit voltage $\mathbf{V_{UN} = 400\ V}$
Line voltage, **3** wire configuration $\mathbf{V_{LN} = 380\ V}$

Calibration voltage: $\mathbf{V_{CA} = 1\ V\ x\ \frac{V_{UN}}{V_{LN}} = 1\ V\ x\ \frac{400\ V}{380\ V} = 1.05\ V}$

The potentiometer **P6** must be turned to obtain **1.05 V** in position **20** on the display.

Example 2: Same conditions as in example **1**, but in **star with neutral** configuration.
Calibration voltage $\mathbf{V_{CA} = 1.05\ V\ x\ \sqrt{3} = 1.82\ V}$
The potentiometer **P6** must be turned to obtain **1.82 V** in position **20** on the display.

Calibration in normal operation mode position (M1 = 1)

The signal read by the diagnostic unit is the **rectified** value, corresponding to the **voltage actually** measured.

In **full** firing (sinusoidal load voltage operation), the DC value read on position **20** must be **1.67 V** (for normal load voltage in full conduction).

Line voltage calibration

The line voltage read by the microprocessor can be adjusted using the potentiometer (labelled **P18**) located on the driver board (see figure 4-2, page 4-7).

Caution !

This setting is made in the factory (**4 V** in point-test **PT11**) and **must not be modified.**

COMMISSIONING

Preliminary settings

- After checking the wiring, make sure that the '**Enable**' input (terminal **15** on the driver board) is connected directly or via a closed contact to '**+10 V**' (terminal **16** on the same terminal block) or to an external voltage between +5 V and + 10 V referenced in relation to terminal **17** ('**0 V**').

- After calibration, check that the Calibration/Operation jumper **M1** are in the operating position (**1**).

- The initial position of the potentiometer **P1** depends on the **thyristor firing mode.**

  - 'Phase angle' operation: turn potentiometer **P1** on the front panel completely **anti-clockwise** (except if the ramp is used).
    This position corresponds to the absence of the ramp.

  - 'Burst firing' operation on the inductive load or on a transformer primary coil: turn potentiometer **P1** completely **clockwise** (**90**° delay in the first thyristor firing).

- Set the potentiometer **P3** ('Setpoint limit') to zero, i.e. completely **anti-clockwise**.
  This position corresponds to the absence of the setpoint signal irrespective of the input signal.

Power-up

During power-up, **automatic recognition of the phase rotation order** is performed for the correct thyristor firing of different phases.

- Switch on the thyristor unit.

Note

If the control power is supplied **before** the power-up, the '**Phase absent**' alarm is displayed.

- Check that the load current is equal to **0** in the **absence** of the control signal.
- Apply a control signal to the input (terminal **14** of the driver board).
- Turn the potentiometer **P3** ('Setpoint limit') slightly clockwise and check that the current increases in the load.

Important !

Depending on the configuration selected using the jumper **K12**, the thyristor unit can start with a **safety ramp** of **32** periods in firing angle variation (see 'Configuration').

This safety ramp is applied at tart:

- at the control electronics **power-up**,
- after an **inhibition**
- after the microprocessor **reset**.

- Make sure that the RMS current does not exceed the nominal thyristor unit current when **the setpoint is 100%** and the potentiometer **P3** is turned completely clockwise.

The control signal can be read in position **7** of the diagnostic unit (**5V** corresponds to **100%**of the input signal).

Delayed firing setting on inductive load

To eliminate the transient operation over-current during the power-up of inductive loads, the first firing on each phase in the 'Burst firing' and 'ON/OFF" modes must be delayed with reference to the corresponding zero voltage (see page 5-9).

The optimum delay angle depends on the load used and can be adjusted with potentiometer **P1** ('**CY Delay**') on the front panel.

In the factory, the delay angle is adjusted to **90°.**

To adjust the delay angle during commissioning, follow the procedure below:

- Check that the position of the jumper **K7** on the driver board is **1** (inductive load) and that the potentiometer **P1** is at the **maximum** value, i.e. turned completely **clockwise**.

- **After** the power-up, turn the potentiometer **P1** slowly **anti-clockwise** until the **transient current** at firing, displayed on the oscilloscope, has a **minimum amplitude.**

Data on the delayed firing angle is available in voltage form in position **11** of the diagnostic unit (**5 V** corresponds to **90°**; the delay angle setting scale is given on page 5-20).

Chapter 7

DISPLAY MESSAGES

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Chapter 7 DISPLAY MESSAGES

GENERAL

During the thyristor unit commissioning procedure and during its operation, messages are displayed on the front panel display. These messages inform the user on:

- the type of thyristor unit operation
- the enabled alarms
- the errors and the failures.

Two types of message are shown on the display.

- **Steady** messages indicating the current thyristor unit operating mode. The thyristor unit operates **normally** or is inhibited.
- **Flashing** messages indicating **abnormal** operation (an error or a failure).

STEADY MESSAGES

Normal operation in **Phase angle** mode

Normal operation in **Burst firing** mode:

Normal operation in **Logic** mode.

Ramp on a setpoint **increase** with thyristor firing angle variation.

Ramp on a setpoint **decrease** with thyristor firing angle variation.

Inhibit of thyristor unit (terminal 15 '**Enable**' on the driver board is at **0 V** or is not connected to **+10V**).

FLASHING MESSAGES

A flashing message is composed of **three consecutive displays** for **1.25 s** each (the second display can be **empty**).

The display indicates two types of flashing message:

- Message '**E**' - an **error**.
  The **next** message indicates the alarm **type**.

- Message '**F**' - a **failure**
  The **next** message indicates the alarm **type**.

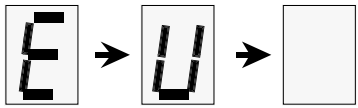
During these messages, **the decimal point** on the display indicates **the alarm ON state.**

The flashing messages are used to **identify** certain alarms.

For the alarm display conditions and their detailed state see '**Alarms**' chapter.

Error

The thyristor unit **continues** to operate.

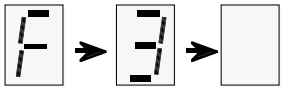


Supply **over-voltage**.
This message disappears at the same time as the over-voltage.

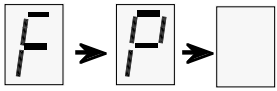
Failures

The detection of the following failures causes operation **inhibit**.
The thyristor unit returns automatically to normal operation as soon as **the cause** of the failure **disappears** (phase missing, frequency, under-voltage) or after an **acknowledgement** (thyristor short-circuit, over-current, external signal failure).

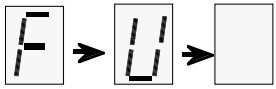
The messages below appear **5 s after** the failure has appeared (except for over-current).



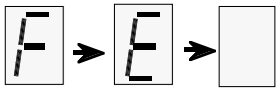
- **One** or **more supply phases** are **missing**.
  The **second** message indicates the **No.** of the missing phase (e.g. phase **3**). If several phases are concerned **only the lowest No.** is displayed).
- Display '**F**' '**1**' : Phase **1** is missing or
  o**ver temperature** detection (thermal switch for fan-cooled unit only ≥ **100 A** nominal)



- Power supply **frequency outside** normal operating limits (**40 to 70 Hz**)
- **Failure** of **neutral circuit** in Star with neutral configuration (fuse blow-out on the power board, etc.)



Under-voltage of supply **V < 70 %** of the **nominal** voltage.
(or V < 50 % depending on the configuration)



External signal return **failure** for control on an external measurement (except in Logic mode).

MICROPROCESSOR FAILURE

The display does not indicate **any** message or indicates **incoherent** messages.
The thyristor unit operation is **inhibited** (by the 'Watchdog') and the driver board must be replaced.

- Microprocessor reset to zero ('**Reset**')
- Thyristor unit initialisation (temporary message).

Chapter 8 ALARMS

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Chapter 8 ALARMS

The alarms used by the TC3000 thyristor unit protect the thyristors and the installation against **abnormal operation** and give the user **information** on the type of failures that have occurred.

Warning !

Alarms cannot be used to replace personnel protection.

It is the user's responsibility and it is highly recommended, given the value of the equipment controlled by the TC3000, to install **independent safety devices which should be checked regularly.**
For this purpose, Eurotherm can supply several types of alarm detectors.

ALARM STRATEGY

The **TC3000** thyristor unit alarms are entirely **managed by the microprocessor** of the driver board which retransmits its data (alarms enabled or not) **using the display** on the thyristor unit front panel and the **alarm relay**.

The alarms are **given levels** (see figure 8-1). The detection of a high level alarm **inhibits** the processing of lower level alarms.

The enabled state of all the alarms is indicated by the front panel **display** (see pages 7-2 to 7-4) and the **alarm relay**.

The **highest** level alarms detect the following failures:

- absence of one or more power supply phases
- under-voltage
- supply frequency deviation
- external measurement signal failure.
- neutral failure (fuse blow-out on the power board).

The detection of one of these failures causes the thyristor unit **operation to be inhibited** (display '**F**' '...').

The low level alarms (display '**E**' '...') monitor the over-voltage **without** a thyristor unit operation inhibit.

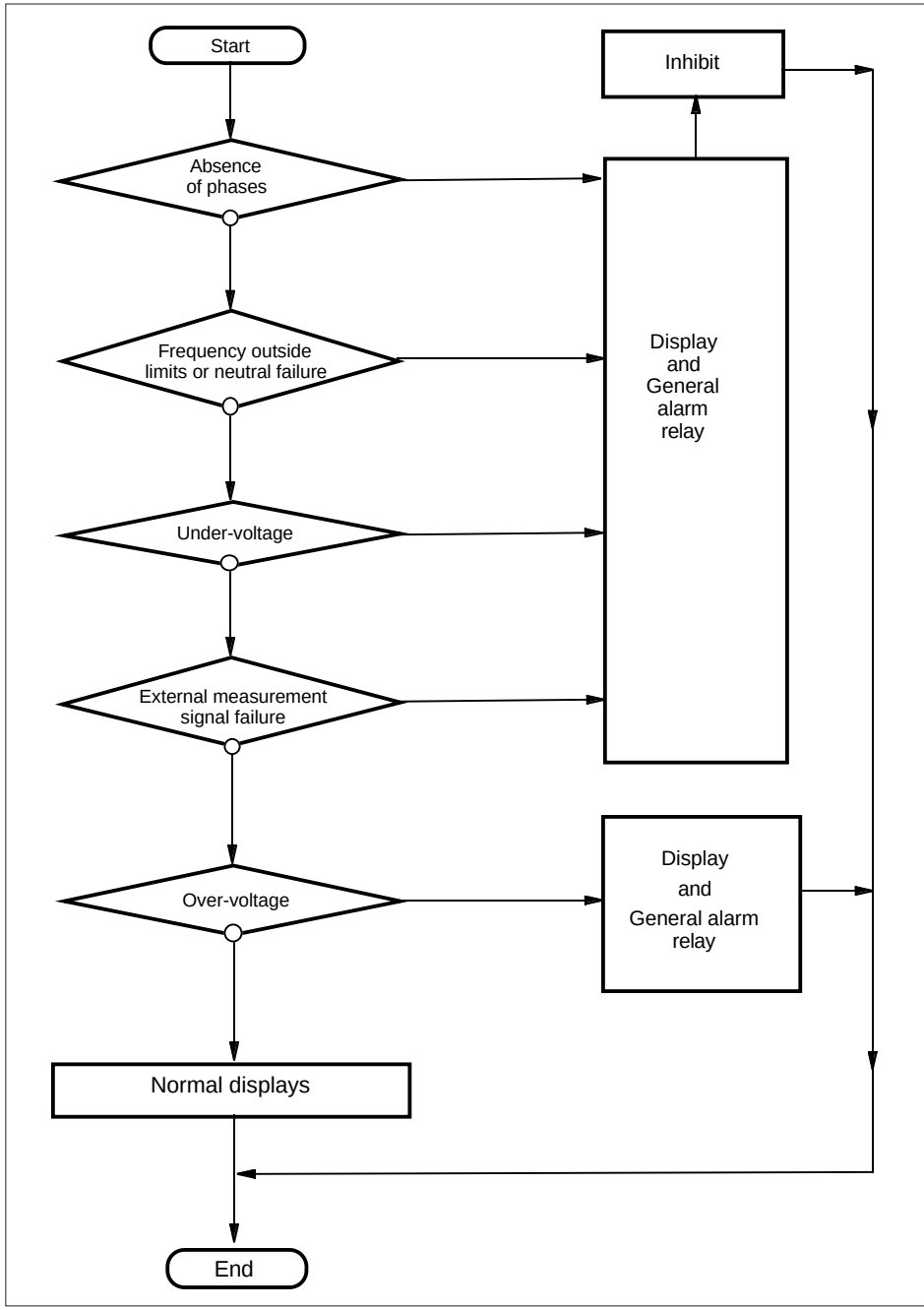

Figure 8-1 Alarm levels and strategy

HIGH LEVEL ALARMS

High level alarms detect the absence of or a significant drop in the power supply voltage, whether the frequency limits have been exceeded, neutral failure in the power board in the star with neutral configuration and external measurement signal failure.

These alarms are integrated for **5 s before being handled**.

High level alarms **stop** the operation of the thyristor unit by **inhibiting** thyristor gate pulses and **activate** the general alarm relay.
Thyristor firing is stopped at the first zero current crossing.

The state of the high level alarms is indicated by **flashing messages** on the front panel display and by the general alarm relay **contact** (N/O or N/C depending on the configuration).

Absence of power supply phases

This alarm appears when one or more power supply phases are absent.
The phase absence alarm can be activated by **power supply** failures, by **fuse** blow-out, by the opening of the **circuit breakers** or line **contactors**, and also by the opening of a permanent cooling thyristor unit safety **thermal switch** (in this case display '**F**' '**1**').

The active alarm state can be seen on the display (messages '**F**' '**1**', '**F**' '**2**' or '**F**' '**3**' depending on the absent phase) and is signalled by the general alarm relay contact.

If several phases are cut off, **a single** message is displayed with the lowest phase number of the absent phase numbers.

The power supply phase absence alarm is not memorised and disappears as soon as the **three phases** are **present**. The thyristor returns to normal operation automatically.

Under-voltage

If the line voltage drops by over **30%** (or **50%** depending on the configuration) in relation to the calibrated nominal value, the under-voltage alarm is detected, which:

- **inhibits** the thyristor unit,
- **activates** the general alarm relay
- displays the flashing message '**F**' '**U**' on the front panel display.

The Under-voltage alarm uses the voltage between phases **1** and **2** as a reference.

This alarm is not memorised and disappears as soon as the power supply voltage is greater than the set threshold. The thyristor unit is started up again automatically, if the voltage returns to over **70%** (or **50%** depending on the configuration) of the nominal voltage.

Frequency error

If the supply frequency is **outside** the normal operating limits (**40** to **70 Hz**), the frequency error alarm:

- **activates** the general alarm relay
- **inhibits** the thyristor unit
- displays the flashing **message** '**F**' '**P**' on the front panel display.

This alarm is not memorised and disappears as soon as the power supply frequency returns to the normal operating limits.

Neutral failure

For the correct operation of the thyristor unit in the **star with neutral** configuration (4 wires), the neutral must be connected to the power board. The **Neutral** user terminal block below the thyristor unit, the neutral **fuse** and the jumper **LK8** on the power board are used for the connection.

In the event of a failure of this circuit or a neutral fuse blow-out (only in 4 wire Star load configurations), the Neutral failure alarm:

- **activates** the general alarm relay
- **inhibits** the thyristor unit
- displays the flashing **message** '**F**' '**P**' on the front panel display.

This alarm is not memorised and disappears as soon as the connection of the neutral to the power board is restored.

External measurement signal failure

This alarm appears when the **absence** of the external measurement signal is detected if control on an external measurement is selected (coding '**EX**' and '**E*****') and the output power **is not zero** (alarm **deactivated** in Logic mode).

The detection of an external signal failure**:**

- **inhibits** the thyristor unit,
- **activates** the general alarm relay,
- displays the message '**F**' '**E**'.

The unit can be restarted after the alarm **acknowledgement**.

LOW LEVEL ALARM

The low level alarm **does not inhibit** the thyristor unit.
The anomaly detected (over-voltage) is displayed with a change in the **relay** contacts and with the message on the **display**.

The low level alarm is only active **5 s after** the corresponding failure has appeared.

If the line voltage is greater than the nominal thyristor unit voltage by more than **20%**, the over-voltage alarm is detected:

- the **general** alarm relay is **activated**,
- the flashing message '**E**' '**U**' appears on the front panel display.

In the event of over-voltage, the thyristor unit **is not inhibited**, the control **keeps** the value of the controlled parameter for the given operating point **constant**.

If the unit returns to a voltage less than **110%** of the nominal thyristor unit voltage, the relay returns to the non-alarm state**.**

ALARM ACKNOWLEDGEMENT

The thyristor unit can only be started up again after inhibition due to memorised alarms (**external measurement failure**) after an acknowledgement.

To acknowledge the alarms, it is possible to:

- switch **off** the auxiliary power supply of the driver board,
- connect terminal **11** ('**Acknowledge**') on the driver board to terminal **16** ('**+10 V**')
- apply a **+10 V** external signal to terminal **11** ('**Acknowledge**').

Alarms can only be acknowledged using terminal **11** when the voltage between phases 1 and 2 is not available (display '**F**' '**1**').

ALARM MANAGEMENT

The main characteristics of all the **TC3000** thyristor unit alarm types and the states of the alarm relays and the thyristors are given in table 8-1.

In this table:

V_{LINE} - RMS line-to-line voltage (line voltage)
V_N - nominal line voltage
V_L - RMS load voltage
V_{LN} - nominal load voltage
V_{EXT} - external measurement signal
OP - input signal (output power)
f - power supply frequency.

Conditions			Inhibit	Display	Acknow-ledge
Alarm	**Alarm ON**	**Alarm OFF**			
Over-voltage	$V_{LINE} > 120\% V_N$	$V_{LINE} \leq 110\% V_N$	No	E U	No
Absence of power supply phases	Absence of synchronisation pulses	After appearance	Yes	F 1 F 2 F 3	No
Under-voltage	$V_{LINE} < 70\% V_N$	$V_{LINE} \geq 70\% V_N$	Yes	F U	No
Frequency error	40 Hz > f > 70 Hz	40 Hz ≤ f ≤ 70 Hz	Yes	F P	No
External meas. signal failure	$V_{EXT} = 0$ $OP \neq 0$	After disappearance	Yes	FE	Yes
Thermal switch (permanent cooling only)	Fan cooling failure	After acknow-ledgement and cooling	Yes	F 1	No
Neutral failure	Neutral fuse blown on neutral not connected (4 wire configuration)	Appearance of neutral circuit	Yes	FP	No

Table 8-1 Alarm characteristics

ALARM RELAYS

The **general alarm relay** is located on the driver board.

The detection of any other alarm changes the state of the general alarm relay.

The contact **(N/O** or **N/C** depending on the configuration) can be used to indicate the alarm state or in the monitoring system.

The contact is available on the user terminal block below the thyristor unit (terminals **61-62**).

The relay contact can be connected without opening the front door of the thyristor unit.

The alarm relay contact connections are given on page 3-12.

The switch cut-off capacity is **0.25 A** (**250 Vac** or **30 Vdc**).

The cut-off voltage must never be greater than **250 Vac**.

The Alarm relay is **deactivated** in the **alarm** state or when the thyristor unit is **switched off**.

Chapter 9

MAINTENANCE

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Chapter 9 MAINTENANCE

Warning !

The thyristor unit must be maintained by qualified personnel only authorised to work in an industrial low voltage electrical environment.

THYRISTOR PROTECTION

The thyristors of the TC3000 series thyristor units are protected as follows:

- internal high speed fuses against over-currents
- RC snubbers and varistors against excessively fast voltage variations and transient over-voltages when the thyristors are not firing.
- thermal switches
  (in the event of accidental overheating of the cooler of fan-cooled thyristor units, the thermal switch opens, which causes the thyristor firing to be stopped).

FUSES

Thyristor protection fuses

The standard version of TC3000 series power thyristor units is supplied with high speed fuses mounted on the line busbar.

Warning !

High speed fuses are only used for the internal protection **of thyristors** against wide amplitude over-loads. These high speed fuses may under no circumstances be used to **protect the installation.**

The user's installation **must be protected upstream** (non-high speed fuses, thermal or electromagnetic circuit breaker, suitable fuse-isolator) and comply with current standards.

Table 9-1 contains all the part numbers of the original internal fuses (when the thyristor unit leaves the factory) and the fuses which can be used for replacements during maintenance.

Maximum line-to-line voltage: **500 V.**

Nominal current		Part No.		
Th. unit	**Fuses**	**EUROTHERM**	**FERRAZ**	**BUSSMANN**
25 A	50 A	LA172468U050	S300373	170M3459
40 A	80 A	LA172468U080	S300051	170M3461
60 A	80 A	LA172468U080	S300051	170M3461
75 A	100 A	LA172468U100	T300052	170M3462
100 A	125 A	LA172468U125	V300053	170M3463
150 A	200 A	LA172468U200	X300055	170M3465
250 A	315 A	LA172468U315	Q300003	170M4460
300 A	400 A	LA172468U400	H300065	170M5458
400 A	500 A	LA172468U500	K300067	170M5460
500 A	630 A	LA172468U630	M300069	170M5462

Table 9-1 Recommended high speed fuses for thyristor protection

Caution !

The use of any fuses **other** than those recommended for thyristor protection **invalidates the thyristor unit guarantee**.

Fuse blown indication micro-switch

As an option, the high speed fuse may be equipped with a fuse blown indication micro-switch (**FUMS** option) with the part No.:

for BUSSMANN fuses:
EUROTHERM DC172267 or FERRAZ P96015 or BUSSMANN 170H0069
for FERRAZ fuses:
EUROTHERM DC172997 or FERRAZ G310 000

To ensure improved isolation between the cabling of the micro-switch terminals and the power and the cover, TC3000 power thyristor units are supplied with three 'flag' type lugs and isolating sleeves.

Each external terminal of the fuse blown indication micro-switch must be cabled with a 'flag' lug and an isolating sleeve in compliance with figure 9-1.

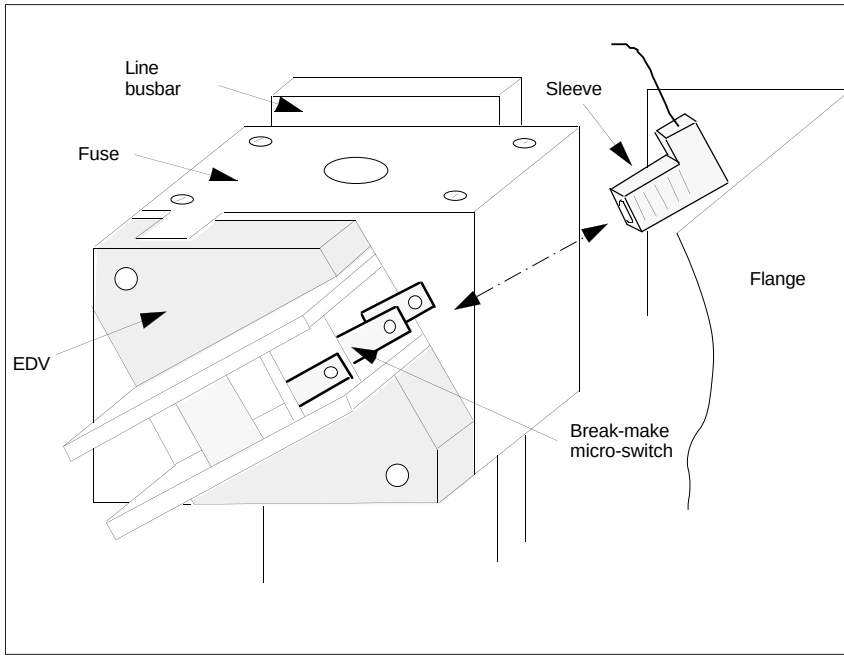

Figure 9-1 Use of "flag" lugs and isolating sleeves to observe isolating distances.

Auxiliary voltage connection protection fuses

These fuses must be installed in the auxiliary voltage connection wires to the phases (see 'Wiring' chapter).

Auxiliary voltage (max)	1 A fuse 6.3 x 32 mm	Fuse-isolator support	'Fuse-Isolator' assembly dimensions (mm)
500 V	CS174289U1A0	CP174293	63 x 15 x 52

Table 9-2 Recommended fuse for auxiliary voltage connection protection

Neutral protection fuse

A neutral protection fuse is mounted on the power board in the Star with neutral configuration (**F1** on figure 4-1, page 4-3).

Operating voltage (max)	Rating	Dimensions	Eurotherm Part No.
500 V	1.6 A	6.3 x 32 mm	CS173676

Table 9-3 Recommended fuse for neutral protection

SERVICING

TC3000 thyristor units must be mounted with the heatsink positioned vertically and with no obstructions either above or below which could block the passage of the ventilation air.

Caution !

If multiple units are installed in the same cabinet, they should be arranged in such a way that the air expelled by one unit **cannot be admitted** into the unit located above it.

In order to ensure correct cooling of the unit, users are advised to **clean the heatsink and the protective grill** of the fans regularly according to the degree of environmental pollution.

Warning !

Every **six months**, check that the screws of the power cables and safety earth are **tightened** correctly (see 'Wiring', page 3-3).

TOOLS

Operation	Flat screw-driver (mm)	Wrench	Electrical equipment
Fixing		Depending on M8 screw heads selected by the customer	
Opening (closing) of front door		CHc No. 4 for M5 screw	
Safety earth connection		HEX17 (M10) HEX19 (M12)	
Power connection (supply side) and fuse change		HEX13 (M8) (25 to 250 A) HEX17 (M10) (300 to 500 A)	
Load connection		HEX17 (M10) (25 to 250 A) HEX19 (M12) (300 to 500 A)	
Cable clamp tightening	0.5 x 3.5		
Control and auxiliary power supply voltage connection	0.5 x 3.5		
Board fixing	0.8 x 5.5	For M4 nut	
Commissioning and calibration	0.4 x 2.5		Ammeter or RMS clip. Oscilloscope (recommended) EUROTHERM type 260 diagnostic unit (recommended)

Table 9-4 Tools